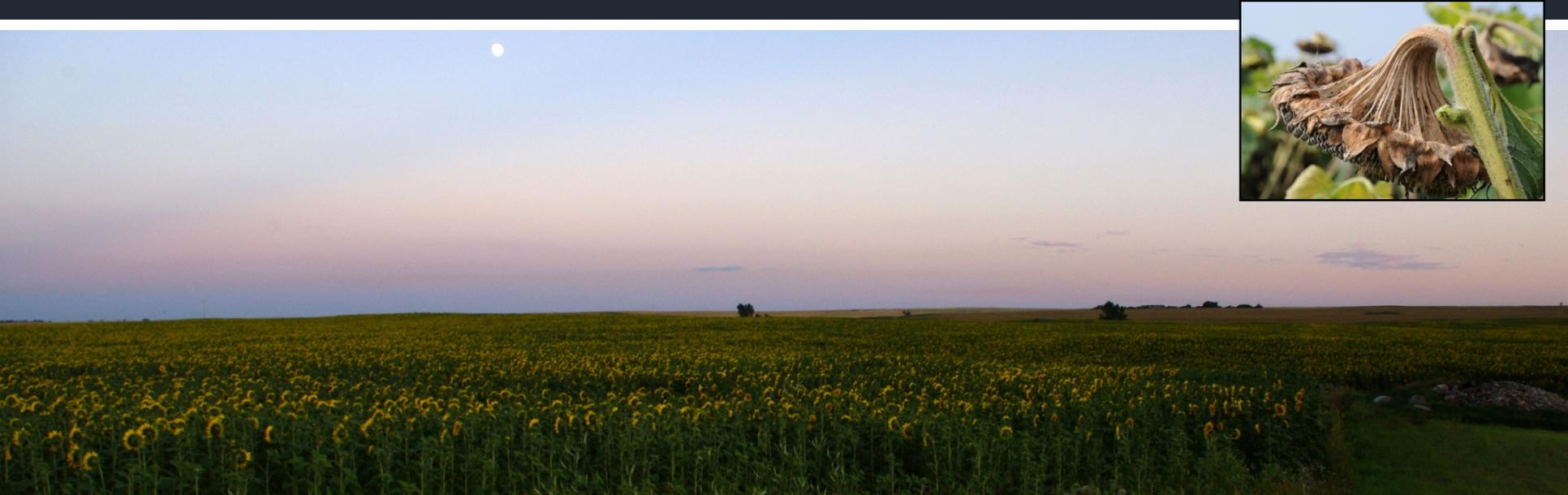


Are fungicides useful for managing *Sclerotinia* head rot in sunflowers?



Michael Wunsch, Jesse Hafner, Billy Kraft, Suanne Kallis, Michael Schaefer, and Thomas Miorini
NDSU Carrington Research Extension Center
Leonard Besemann, Kelly Cooper, Heidi Eslinger
NDSU Robert Titus Research Farm, Oakes
Scott Halley, Amanda Arens and Pravin Gautam
NDSU Langdon Research Extension Center

Fungicide efficacy testing

INITIAL FUNGICIDE EFFICACY TESTING (2011-2013)

Applications made with a hand-held boom

- Testing conducted in Carrington, Oakes, Langdon, ND; Scottsbluff, NE
- Fungicide efficacy and application frequency evaluated

FUNGICIDE APPLICATION TIMING: early bloom (R5.1-R5.5) and before pathogen inoculation

PLOT SIZE: **2012, 2013:** 127.5-130 sq ft (Oakes, Langdon), 145-150 sq ft (Carrington, Scottsbluff); **2011:** 55 sq ft (Langdon), 100 sq ft (Carrington)

DESIGN: Completely randomized block with 4 replicates

INOCULATION: approx. 15,000 ascospores of *S. sclerotiorum* applied to the front of heads after fungicides were applied; each head inoculated two or three times during bloom

SUPPLEMENTAL IRRIGATION: overhead irrigation initiated after fungicides were applied; micro-sprinklers set on a timer, with water delivered as needed to keep front of heads moist through R5 and R6 growth stages

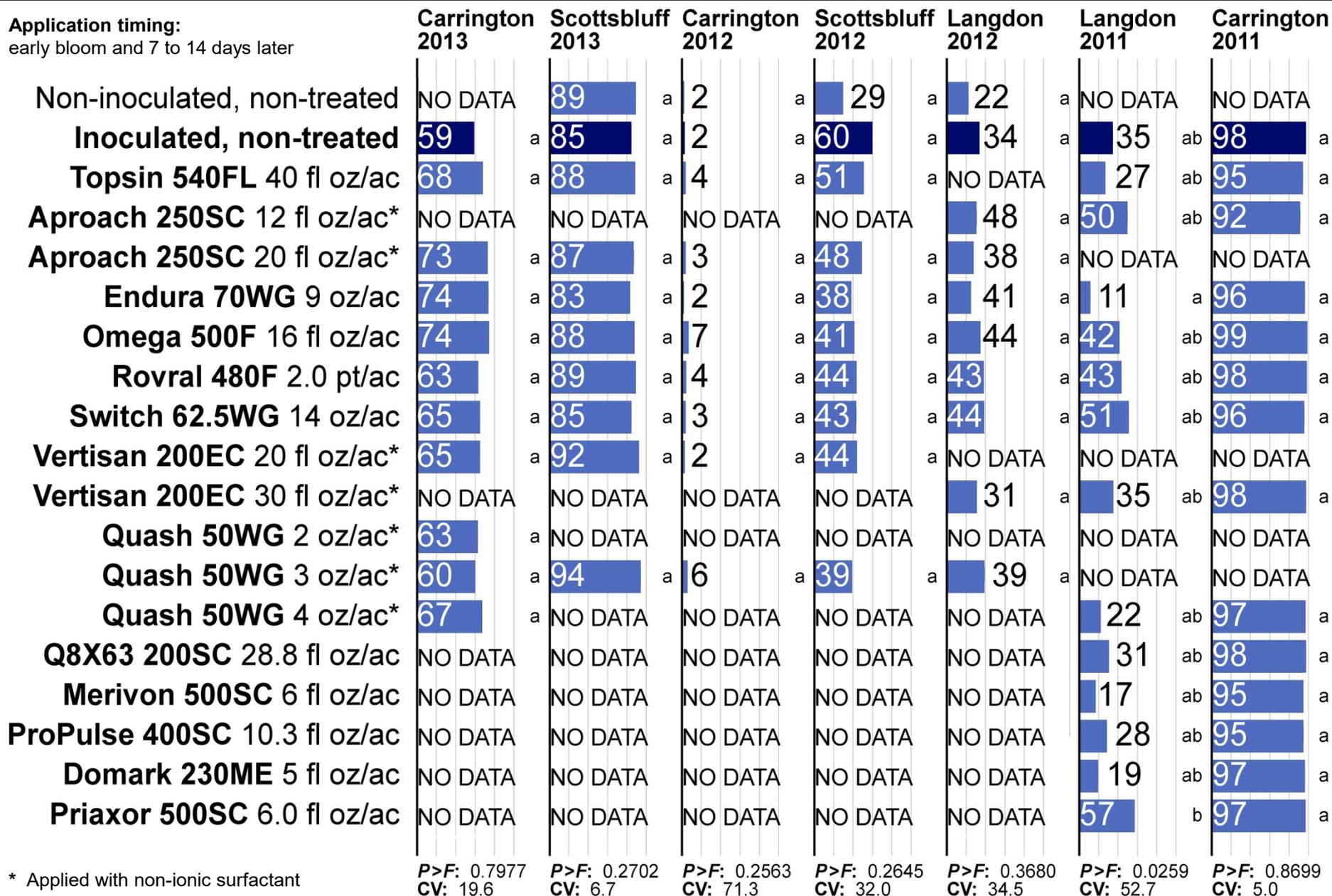
FUNGICIDE APPLICATIONS: Hand-held boom equipped with flat-fan 8001 or 8002 nozzles, Minimum 14.5 gallons of water/ac, generally 30 or 35 psi



Fungicide efficacy testing, applications made with a hand-held boom

SCLEROTINIA HEAD ROT INCIDENCE (%)

Application timing:
early bloom and 7 to 14 days later



* Applied with non-ionic surfactant

P>F: 0.7977
CV: 19.6

P>F: 0.2702
CV: 6.7

P>F: 0.2563
CV: 71.3

P>F: 0.2645
CV: 32.0

P>F: 0.3680
CV: 34.5

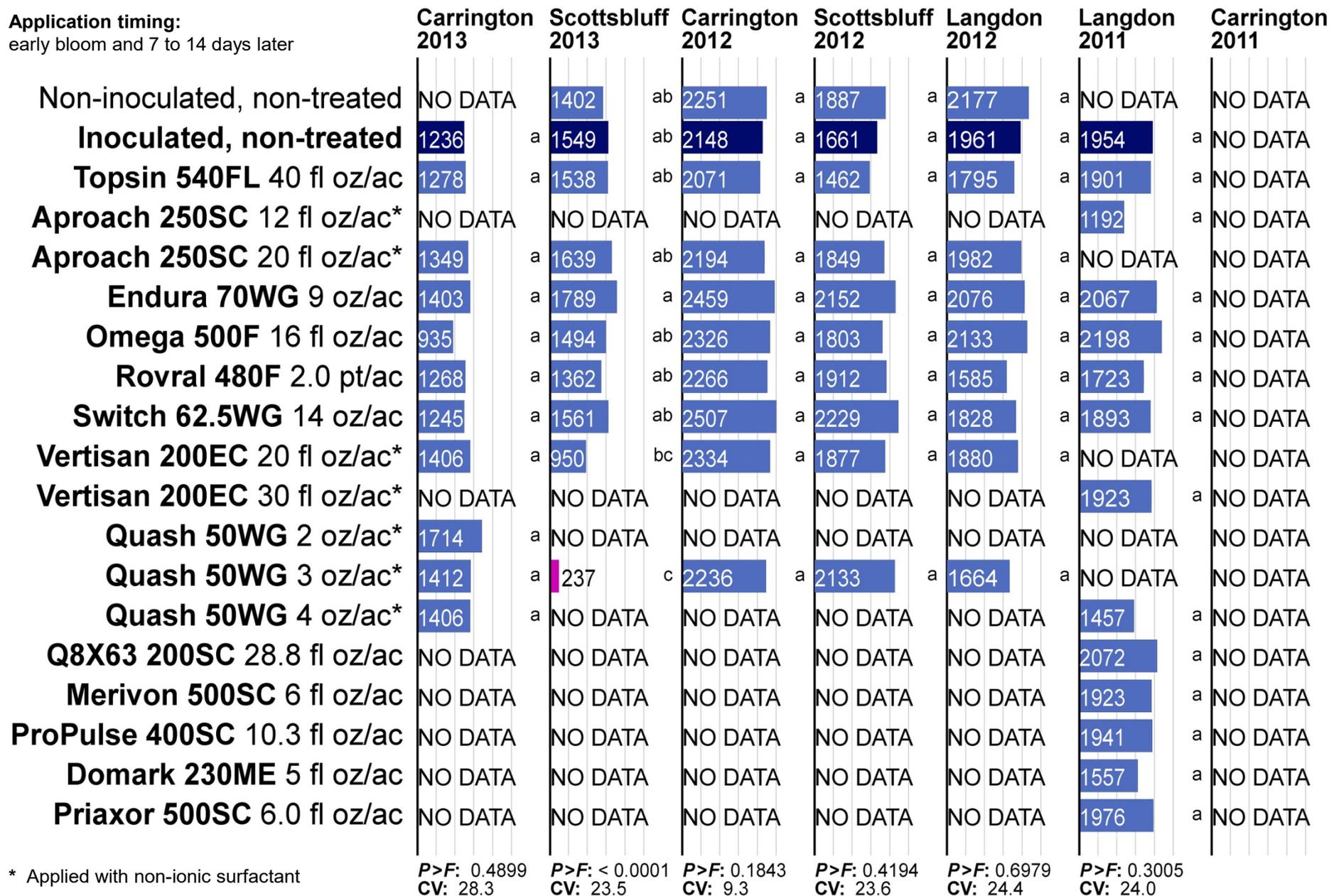
P>F: 0.0259
CV: 52.7

P>F: 0.8699
CV: 5.0

Fungicide efficacy testing, applications made with a hand-held boom

YIELD (pounds/acre)

Application timing:
early bloom and 7 to 14 days later



* Applied with non-ionic surfactant

P>F: 0.4899
CV: 28.3

P>F: < 0.0001
CV: 23.5

P>F: 0.1843
CV: 9.3

P>F: 0.4194
CV: 23.6

P>F: 0.6979
CV: 24.4

P>F: 0.3005
CV: 24.0

Fungicide application frequency testing, applications with hand-held boom

ONE vs. TWO vs. THREE APPLICATIONS

Application timing:

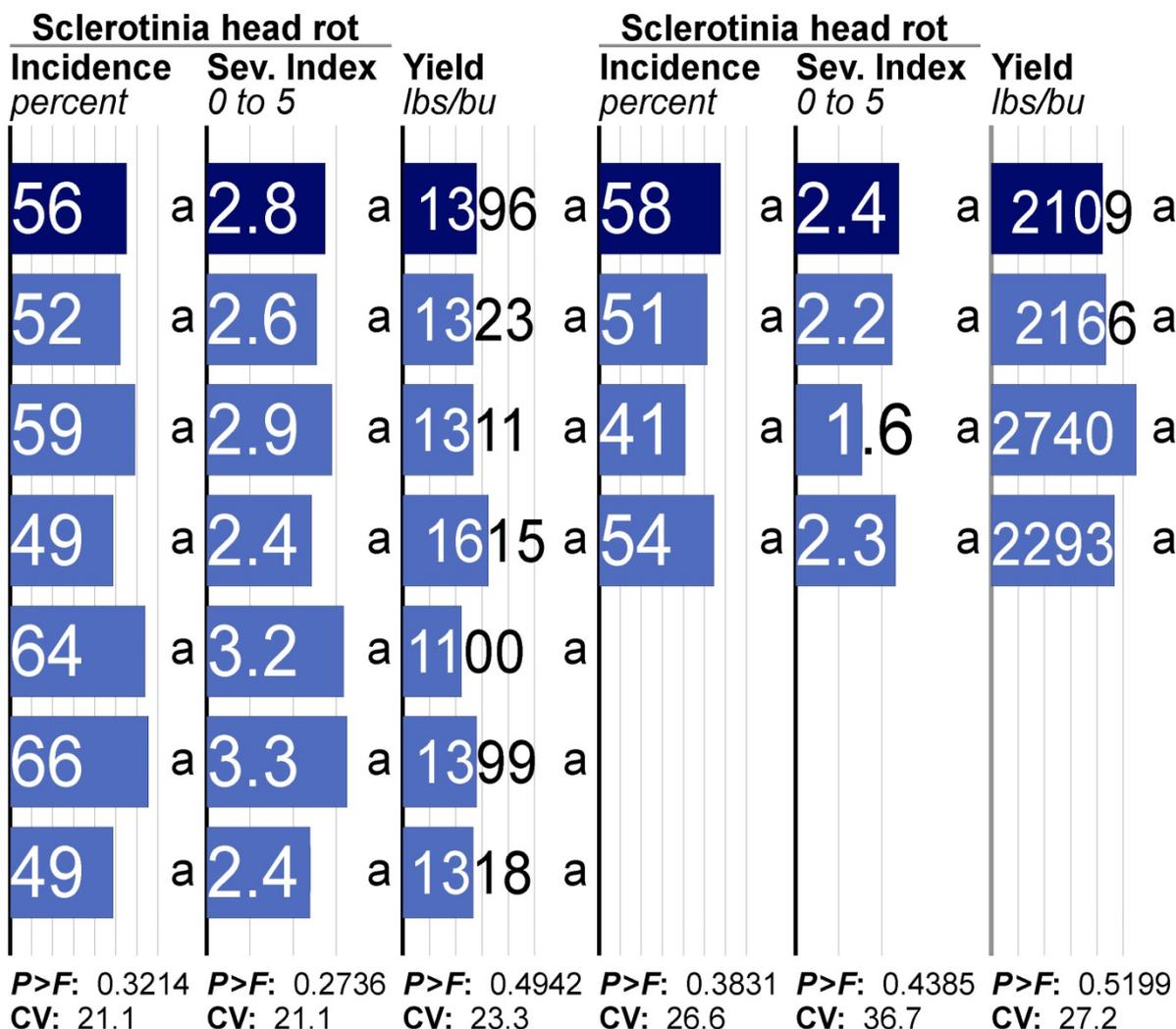
(A): early bloom (R5.1-R5.5)

(B): 10-12 days after application A

(C): 8-10 days after application B

Carrington, ND (2013)

Oakes, ND (2013)



Fungicide efficacy testing

INITIAL FUNGICIDE EFFICACY TESTING (2011-2013)

Applications made with a hand-held boom

WHEN APPLIED ACROSS THE TOP OF THE CANOPY WITH A HAND-HELD BOOM, FOLIAR FUNGICIDES EXHIBITED LITTLE OR NO EFFICACY AGAINST SCLEROTINIA HEAD ROT

The poor efficacy was likely due to the difficulty of achieving satisfactory fungicide coverage.



Sam Markell

Fungicide efficacy testing

TRACTOR-MOUNTED HIGH-CLEARANCER SPRAYER (2015)
Boom-mounted nozzles versus drop nozzles

Can fungicide coverage and disease control be improved by delivering fungicides through drop nozzles mounted on a high-clearance sprayer?

- **Confection hybrid:** NuSeed 'Jaguar'; **Oilseed hybrid:** Croplan '305 NS DMR'
- **Fungicide applied:** Endura (boscalid) at 8 oz/ac
- **Water volume,** fungicide applications: 20 gal/ac
- **Fungicide application timing, confection hybrid:** 82% of plants with open ray flowers; among plants in bloom, average R5.3 (average 30% of disk flowers blooming or already completed bloom)
- **Fungicide application timing, oilseed hybrid:** 80% of plants with open ray flowers; among plants in bloom, average R5.3 (average 30% of disk flowers blooming or already completed bloom)
- **Four inoculation treatments:** Non-inoculated, early bloom, mid-bloom, late bloom. **Five replications.** Plots 5 ft x 25 ft.

Fungicide efficacy testing – tractor-mounted high-clearance boom (2015)

**Drop nozzle from 360 Yield Center:
'360 Undercover'**

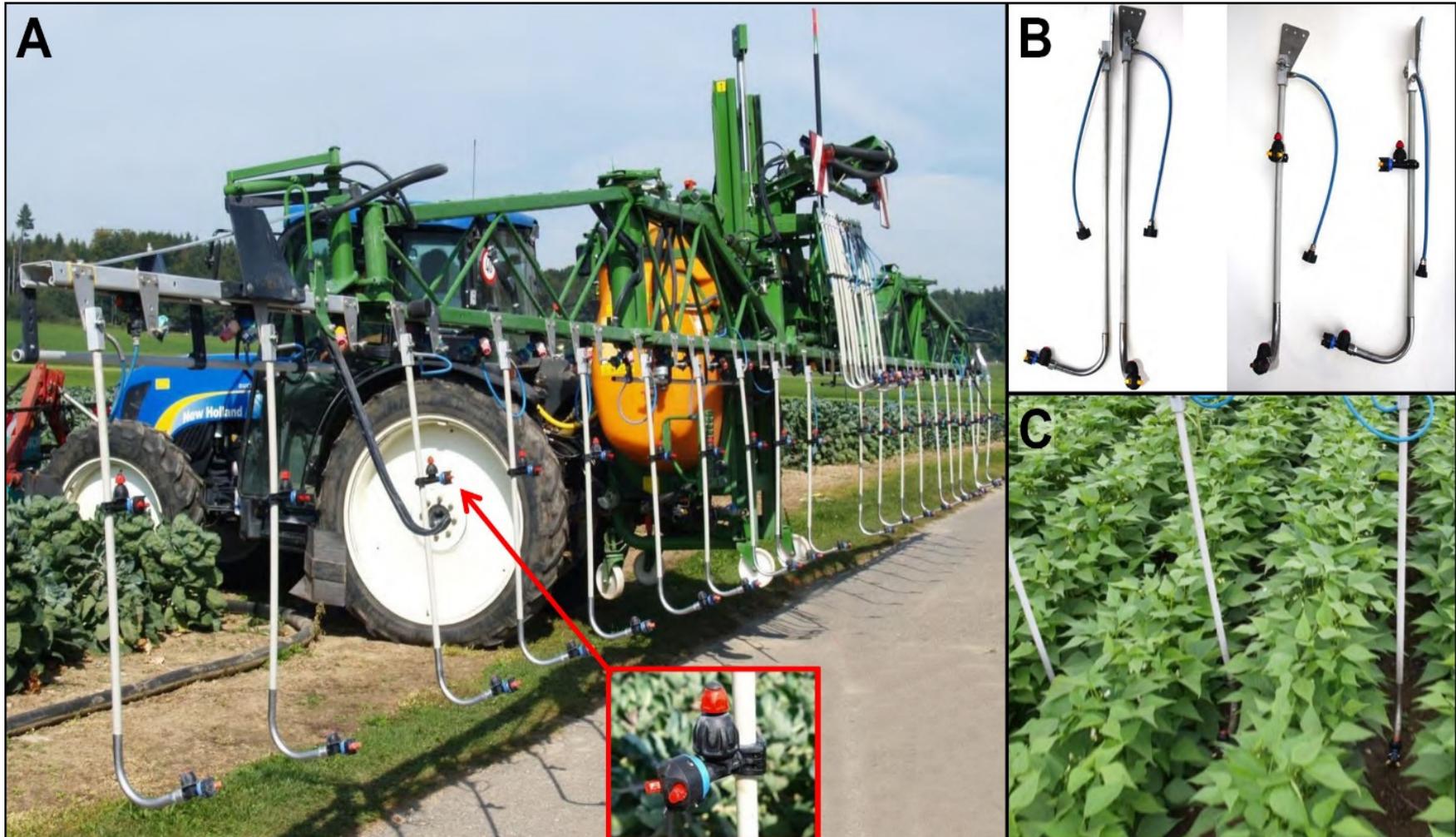


- Ⓞ SENSE
- Ⓞ DECIDE
- Ⓞ APPLY



Fungicide efficacy testing – tractor-mounted high-clearance boom (2015)

- **Drop nozzles from Kuhn Landmaschinen: ‘FK 90 Plus 1’ and ‘FK 110 Plus 2’**



Assessment of fungicide coverage:

- **Three rows were treated with fungicide:** two rows were used to evaluate disease & yield response, and one row was used to evaluate fungicide spray coverage
- **‘Spray cards’** (water-sensitive paper designed for assessing spray coverage) were attached to the front of five heads per plot in each of 3 replicates

Fungicide efficacy testing – tractor-mounted high-clearance boom (2015)

FUNGICIDE COVERAGE TO FRONT OF HEADS - CONFECTION HYBRID

'Jaguar DMR'; application timing: 82% of plants with open ray flowers; among plants in bloom, average R5.3 growth stage (30% of disk flowers in bloom or completed bloom)

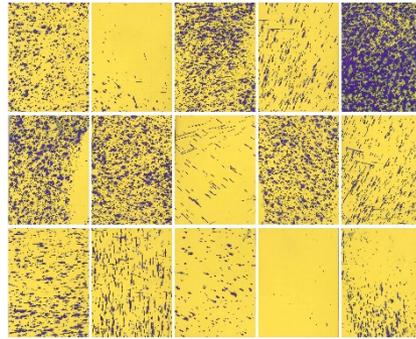
BOOM-MOUNTED NOZZLES

Turbo TeeJet TT11001
40 psi (medium droplets)



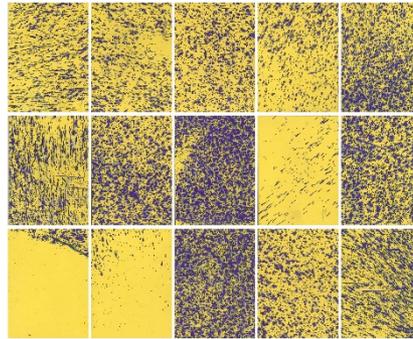
SIDE PORTS OF '360 UNDERCOVER'

Turbo TeeJet TT11001
40 psi (medium droplets)



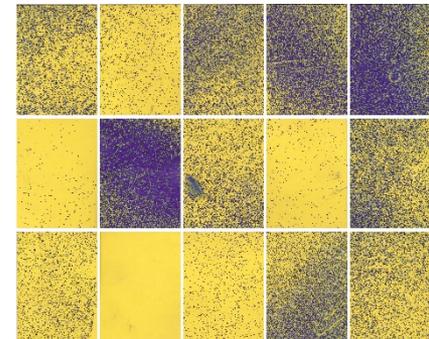
SIDE PORTS OF '360 UNDERCOVER'

Turbo TeeJet TT11001
60 psi (fine droplets)



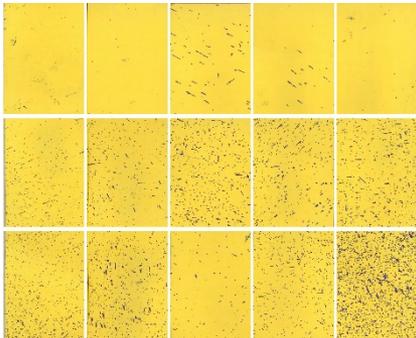
SIDE PORTS OF '360 UNDERCOVER'

ConeJet TXR8001 hollow-cone
60 psi (very fine droplets)



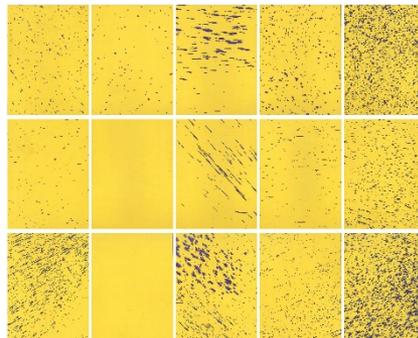
FK90 PLUS 1 DROP NOZZLES

Hypro 0.5 DeflecTip flood-fan
nozzles, 40 psi (fine droplets)



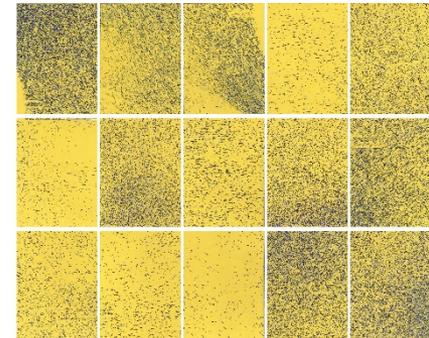
FK110 PLUS 2 DROP NOZZLES

Hypro 0.5 DeflecTip flood-fan
nozzles, 40 psi (fine droplets)



SIDE PORTS OF '360 UNDERCOVER'

ConeJet TXR8001 hollow-cone
60 psi (very fine droplets)
Sprayer driven opposite direction



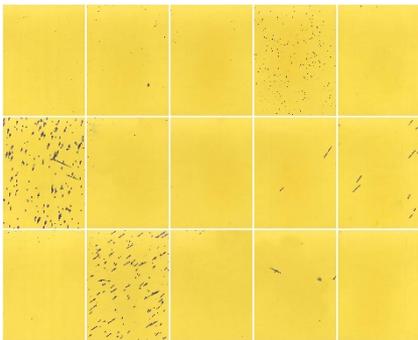
Fungicide efficacy testing – tractor-mounted high-clearance boom (2015)

FUNGICIDE COVERAGE TO FRONT OF HEADS - OILSEED HYBRID

'Croplan 305'; application timing: 80% of plants with open ray flowers; among plants in bloom, average R5.3 growth stage (30% of disk flowers in bloom or completed bloom)

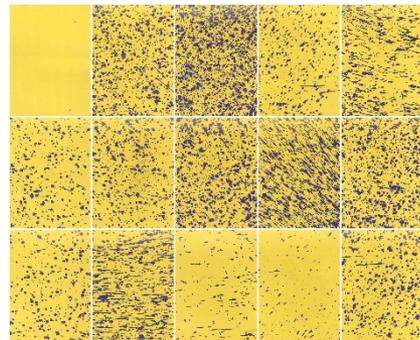
BOOM-MOUNTED NOZZLES

Turbo TeeJet TT11001
40 psi (medium droplets)



SIDE PORTS OF '360 UNDERCOVER'

Turbo TeeJet TT11001
40 psi (medium droplets)

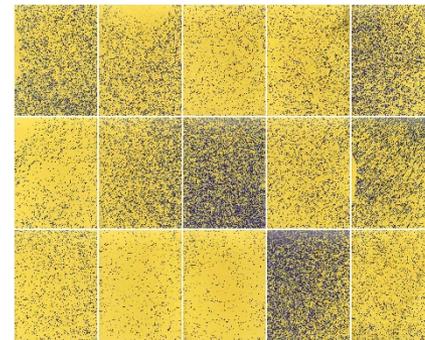


SIDE PORTS OF '360 UNDERCOVER'

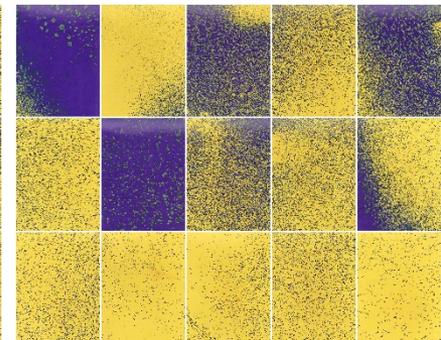
ConeJet TXR8001 hollow-cone

60 psi (very fine droplets)

Normal driving direction

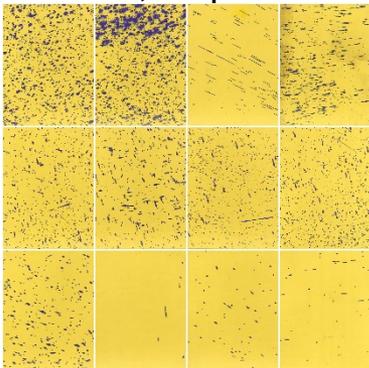


Opposite driving direction



FK90 PLUS 1 DROP NOZZLES

Hypro 0.5 DeflecTip flood-fan
nozzles, 40 psi



Fungicide efficacy testing – tractor-mounted high-clearance boom (2015)

CONFECTION SUNFLOWER HYBRID:

Combined results across all pathogen inoculation timings
(non-inoculated + inoculated once after fungicides applied at early, mid or late bloom)

Head rot incidence	Head rot sev. index	Yield
R8 to R9 growth stage		
Sept. 30		
%	%	lbs/ac

Nozzle placement	Nozzle	Pressure	Head rot incidence	Head rot sev. index	Yield
Non-treated			36 a*	35 a*	1668 a*
Boom (20-inch spacing)	Turbo TeeJet TT11001	40 psi	37 a	36 a	1794 a
Side ports of '360 Undercover' drop nozzle	Turbo TeeJet TT11001	40 psi	37 a	37 a	1753 a
Side ports of '360 Undercover' drop nozzle	Turbo TeeJet TT11001	60 psi	36 a	36 a	1719 a
Side ports of '360 Undercover' drop nozzle	ConeJet TXR8001VK	60 psi	39 a	39 a	1666 a
Side ports of '360 Undercover' drop nozzle	ConeJet TXR8001VK	60 psi	39 a	38 a	1716 a
'FK 90 Plus 1' drop nozzle	30DT 0.5 DeflecTip	40 psi	41 a	40 a	1749 a
'FK 110 Plus 2' drop nozzle	30DT 0.5 DeflecTip	40 psi	38 a	38 a	1744 a

<i>F</i> :	0.61	0.61	0.59
<i>P>F</i> :	0.7455	0.7455	0.7608
<i>CV</i> :	24.9	25.0	14.7

OILSEED SUNFLOWER HYBRID:

Combined results across all pathogen inoculation timings
(non-inoculated + inoculated once after fungicides applied at early, mid or late bloom)

Head rot incidence	Head rot sev. index
Oct. 14 R9 growth stage	
%	%

Nozzle placement	Nozzle	Pressure	Head rot incidence	Head rot sev. index
Non-treated			29 a*	28 a*
Boom (20-inch spacing)	Turbo TeeJet TT11001	40 psi	22 a	22 a
Side ports of '360 Undercover' drop nozzle	Turbo TeeJet TT11001	40 psi	27 a	27 a
Side ports of '360 Undercover' drop nozzle	ConeJet TXR8001VK	60 psi	28 a	28 a
Side ports of '360 Undercover' drop nozzle	ConeJet TXR8001VK	60 psi	25 a	24 a
'FK 90 Plus 1' drop nozzle	30DT 0.5 DeflecTip	40 psi	26 a	24 a

NO YIELD DATA due to severe lodging associated with a wind storm

<i>F</i> :	0.81	0.83
<i>P>F</i> :	0.5451	0.5306
<i>CV</i> :	42.8	43.1

Fungicide: Endura 8 oz/ac **Application timing:** 80-82% of plants with open ray flowers and average R5.3 among plants in bloom

Fungicide efficacy testing

TRACTOR-MOUNTED HIGH-CLEARANCER SPRAYER (2015) Boom-mounted nozzles versus drop nozzles

WHEN THE FUNGICIDE ENDURA (8 oz/ac) WAS APPLIED WITH DROP NOZZLES OR BOOM-MOUNTED NOZZLES at EARLY BLOOM, FOLIAR FUNGICIDES EXHIBITED LITTLE OR NO EFFICACY AGAINST SCLEROTINIA HEAD ROT

Poor fungicide efficacy was observed even with good fungicide coverage. Results were the same irrespective of whether sunflowers were inoculated or when they were inoculated.

QUESTIONS: Was the fungicide application timing sub-optimal?
Should a different fungicide be utilized?



Fungicide efficacy testing

TRACTOR-MOUNTED HIGH-CLEARANCER SPRAYER (2016)
Boom-mounted nozzles versus drop nozzles

Can disease control be improved by using a different fungicide? How much residual activity is there?

- **Confection hybrid:** NuSeed 'Jaguar'
- **Fungicide:** Proline (prothioconazole) at 5.7 fl oz/ac + Silkin NIS 0.25% v/v
- **Water volume,** fungicide applications: 15 gal/ac
- **Fungicide application timing, Oakes:** 97% of plants with open ray flowers; among plants in bloom, average R5.6 (average 60% of disk flowers blooming or already completed bloom)
- **Fungicide application timing, Carrington:** 100% of plants with open ray flowers; among plants in bloom, average R5.6 (average 30% of disk flowers blooming or already completed bloom)
- **Two inoculation treatments:** 1 or 3-4 days after fungicides were applied

Fungicide efficacy testing

TRACTOR-MOUNTED HIGH-CLEARANCER SPRAYER (2016) Boom-mounted nozzles versus drop nozzles

OAKES, ND:

Nozzle Placement	Spray Pattern	Nozzles utilized (Spraying Systems TeeJet)	Application Pressure	Droplet Size	Driving Speed	Driving Direction	Fungicide coverage %	
1	Non-treated control							
2	Boom-mounted nozzles	flat fan	XR8001VS at 20-inch spacing	40 psi	Fine	2.0	0 b*‡	
3	Undercover 360 drop nozzle	flat fan	XR11001VS on side ports	40 psi	Fine	2.6	East (90° from the north)	5 ab
4	Undercover 360 drop nozzle	flat fan	XR11001VS on side ports	40 psi	Fine	2.6	West (270° from the north)	2 ab
5	Undercover 360 drop nozzle	flat fan	XR11001VS on side ports	60 psi	Very Fine	3.2	East (90° from the north)	3 ab
6	Undercover 360 drop nozzle	flat fan	XR11001VS on side ports	60 psi	Very Fine	3.2	West (270° from the north)	4 ab
7	Undercover 360 drop nozzle	hollow cone	TX-VK3 on side ports	60 psi	Very Fine	1.6	East (90° from the north)	17 a
8	Undercover 360 drop nozzle	hollow cone	TX-VK3 on side ports	60 psi	Very Fine	1.6	West (270° from the north)	8 ab

FUNGICIDE APPLIED AUGUST 5 (ave. R5.6)				FUNGICIDE APPLIED AUGUST 5 (ave. R5.6)			
SUNFLOWERS INOCULATED AUGUST 6 (R5.7)				SUNFLOWERS INOCULATED AUGUST 8 (R5.9)			

Nozzle Placement	Nozzles utilized (Spraying Systems TeeJet)	Sclerotinia head rot		Yield	Sclerotinia head rot		Yield		
		Incidence (%) R9 growth stage	Rust Sev. Index (%) Sept. 15; R8	lbs/ac	Incidence (%) R9 growth stage	Rust Sev. Index (%) Sept. 15; R8	lbs/ac		
1	Non-treated	97 a*	8.8 b*‡	594 a*	83 a*	4.8 b*‡	891 b*		
2	Boom-mounted	XR8001VS at 20-inch spacing	40 psi	94 a	0.0 a	613 a	59 a	0.1 a	1468 ab
3	drop nozzle	XR11001VS on side ports	40 psi	92 a	0.1 a	1058 a	78 a	0.1 a	1638 a
4	drop nozzle	XR11001VS on side ports	40 psi	95 a	0.1 a	576 a	74 a	0.0 a	1052 ab
5	drop nozzle	XR11001VS on side ports	60 psi	92 a	0.1 a	998 a	72 a	0.4 ab	1612 a
6	drop nozzle	XR11001VS on side ports	60 psi	95 a	0.1 a	283 a	82 a	0.1 a	834 b
7	drop nozzle	TX-VK3 on side ports	60 psi	93 a	0.2 a	973 a	64 a	0.2 a	1565 ab
8	drop nozzle	TX-VK3 on side ports	60 psi	89 a	0.0 a	779 a	79 a	0.1 a	1260 ab

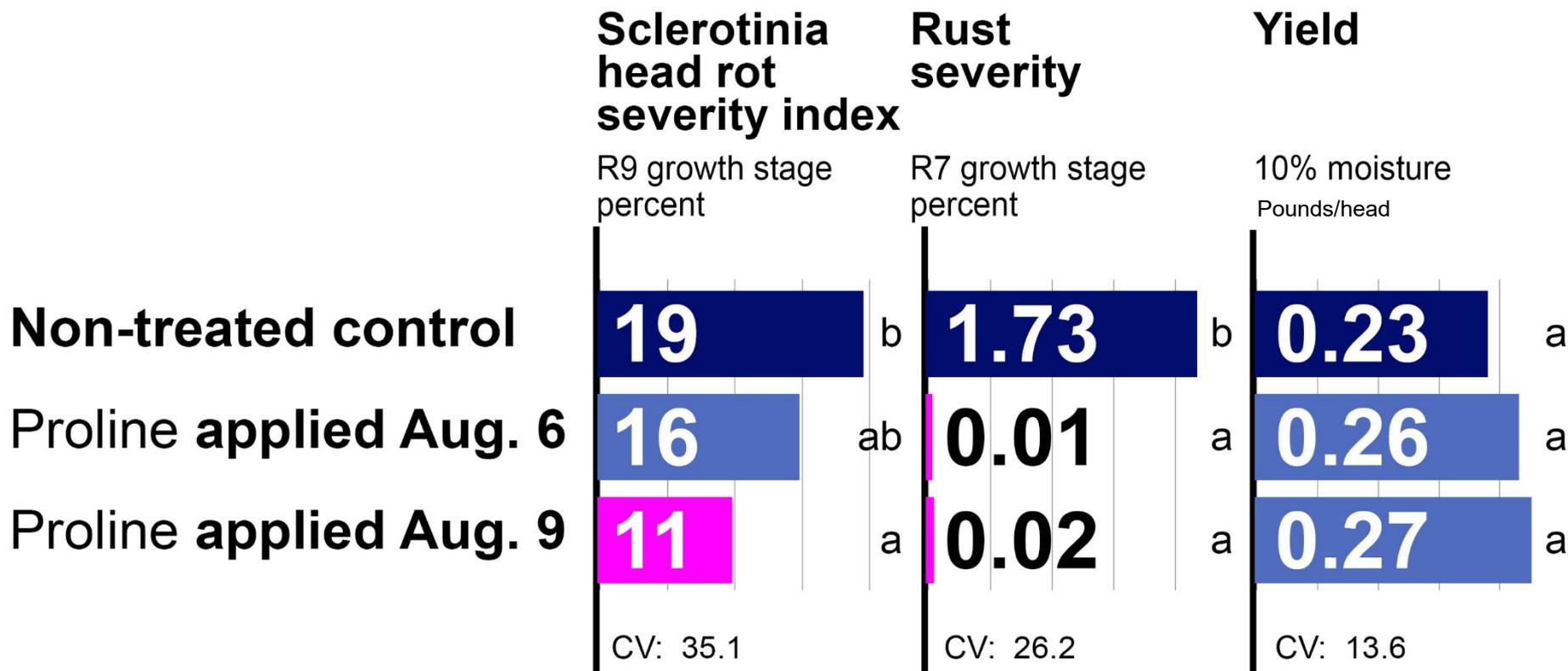
F:	1.26	126.95	1.89	1.83	4.00	3.57
P>F:	0.3172	< 0.0001	0.1282	0.1342	0.0063	0.0110
CV:	4.5	42.3	42.1	17.1	172.3	26.2

Fungicide efficacy testing

TRACTOR-MOUNTED HIGH-CLEARANCER SPRAYER (2016) Boom-mounted nozzles versus drop nozzles

CARRINGTON, ND:

Sunflowers inoculated on August 10 when sunflowers were at predominant R5.8-R5.9 growth stage. Fungicides were applied August 6 (average R5.3 growth stage) or August 9 (average R5.8)



Fungicide efficacy testing

TRACTOR-MOUNTED HIGH-CLEARANCER SPRAYER (2016)

Boom-mounted nozzles versus drop nozzles

Conclusion, studies conducted in 2016:

Proline may exhibit some efficacy against head rot but have very poor residual activity

Fungicide testing - 2017

Disease establishment

- **Pathogen inoculation:**
 - Carrington – single inoculation (22,500 ascospores/head)
 - Oakes – two inoculations (30,000 ascospores/head)
- **Overhead irrigation:**
 - micro-sprinkler irrigation mist systems
 - intensively irrigation at R5 and R6 growth stages
 - moderate irrigation at R7 growth stage

Fungicide Efficacy - 2017

Oakes, ND: sunflowers at average R5.4 growth stage

**Sclerotinia
Head Rot
Severity Index**

Percent of sunflower
head tissue diseased

Oct. 10 | R9 growth stage

**Rust
Severity**

Percent of leaf area
covered by rust pustules;
4th leaf from top of plant

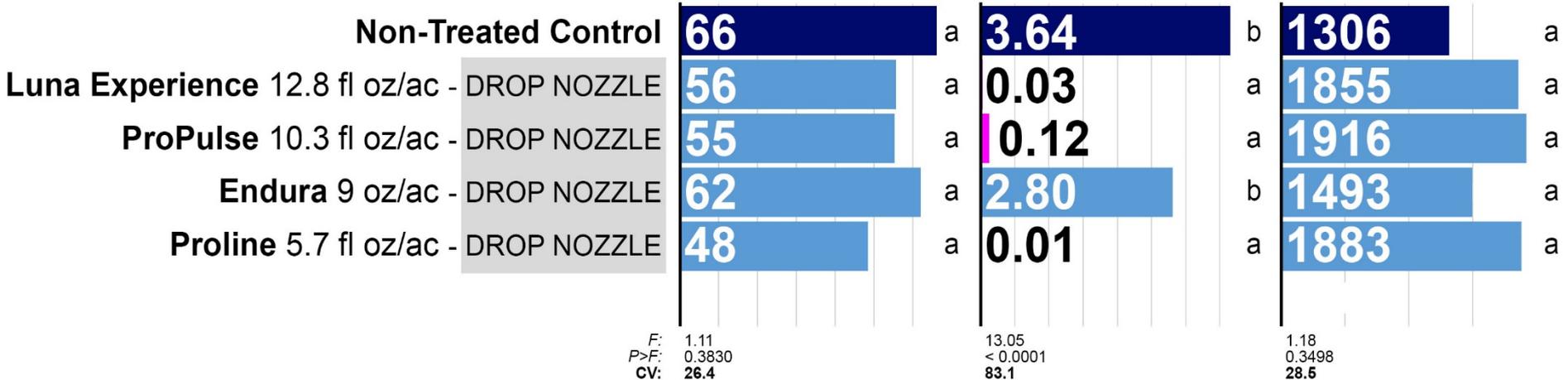
Sept. 7 | R7 growth stage

**Sunflower
Yield**

10% moisture

pounds / acre

Sunflower heads inoculated with ascospores of *S. sclerotiorum* 2 and 3 days after fungicides were applied



Spray nozzles, application pressure:

- Drop nozzle: XR11002 (flat-fan) nozzles on side ports; 40 psi

Fungicide Efficacy - 2017

Carrington, ND: sunflowers at average R5.5 growth stage

Spray nozzles, application pressure:

- Drop nozzle: XR11002 (flat-fan) nozzles, side ports; 40 psi
- Boom-mounted nozzles: XR11002 (flat-fan) nozzles; 40 psi

Sclerotinia Head Rot Severity Index

Percent of sunflower head tissue diseased

Oct. 16 | R9 growth stage

Rust Severity

Percent of leaf area covered by rust pustules; 4th leaf from top of plant

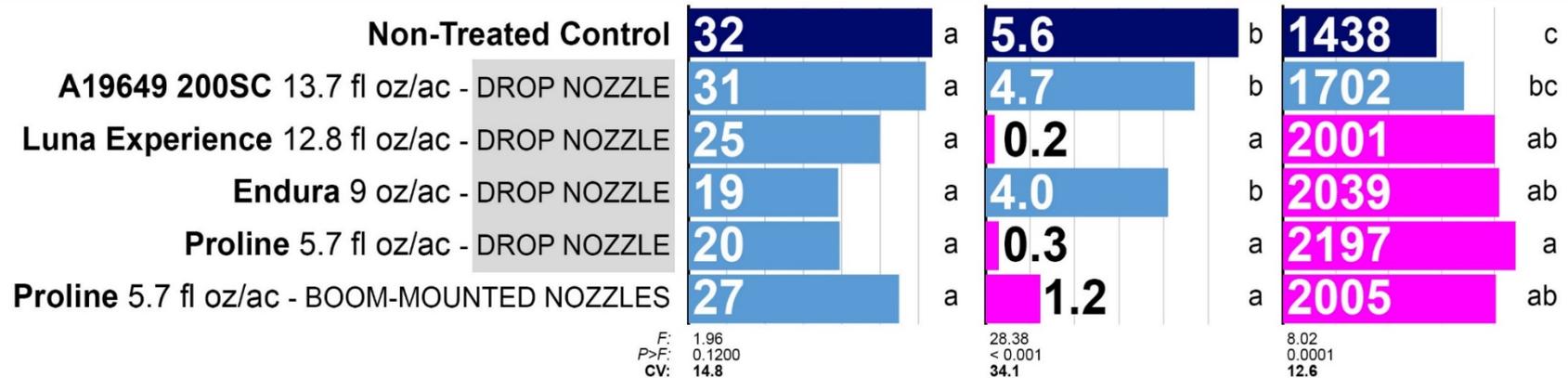
Sept. 25 | R7/R8 gr. stage

Sunflower Yield

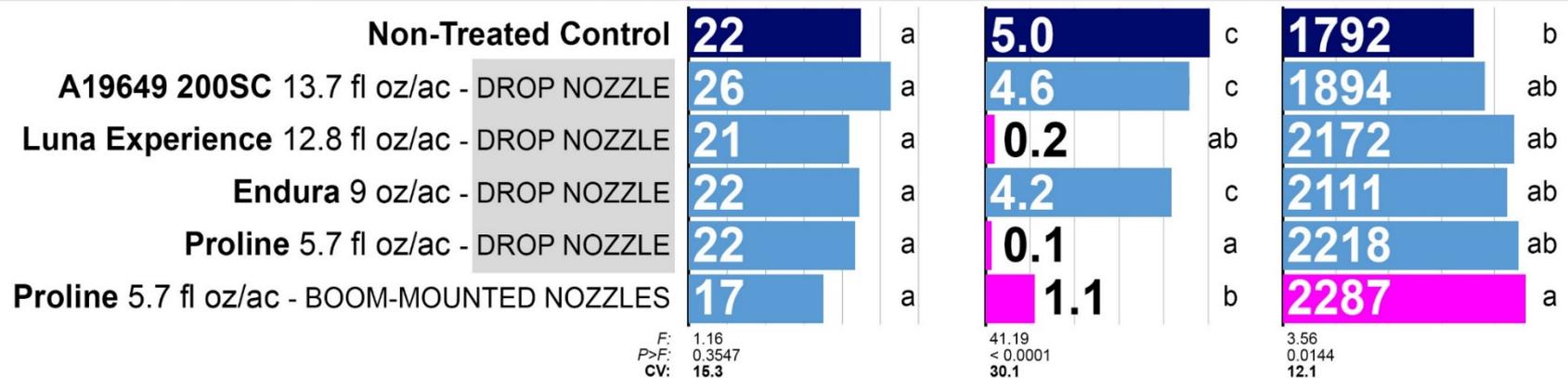
10% moisture

pounds / acre

1. Sunflower heads inoculated with ascospores of *Sclerotinia sclerotiorum* 2 days after fungicides were applied



2. Sunflower heads inoculated with ascospores of *Sclerotinia sclerotiorum* 7 days after fungicides were applied



Fungicide Efficacy - 2017

Carrington, ND: sunflowers at average R5.7 growth stage

Spray nozzles, application pressure:

- Drop nozzle: XR11002 (flat-fan) nozzles, side ports; 40 psi
- Boom-mounted nozzles: XR11002 (flat-fan) nozzles; 40 psi

Sclerotinia Head Rot Severity Index

Percent of sunflower head tissue diseased

Oct. 16 | R9 growth stage

Rust Severity

Percent of leaf area covered by rust pustules; 4th leaf from top of plant

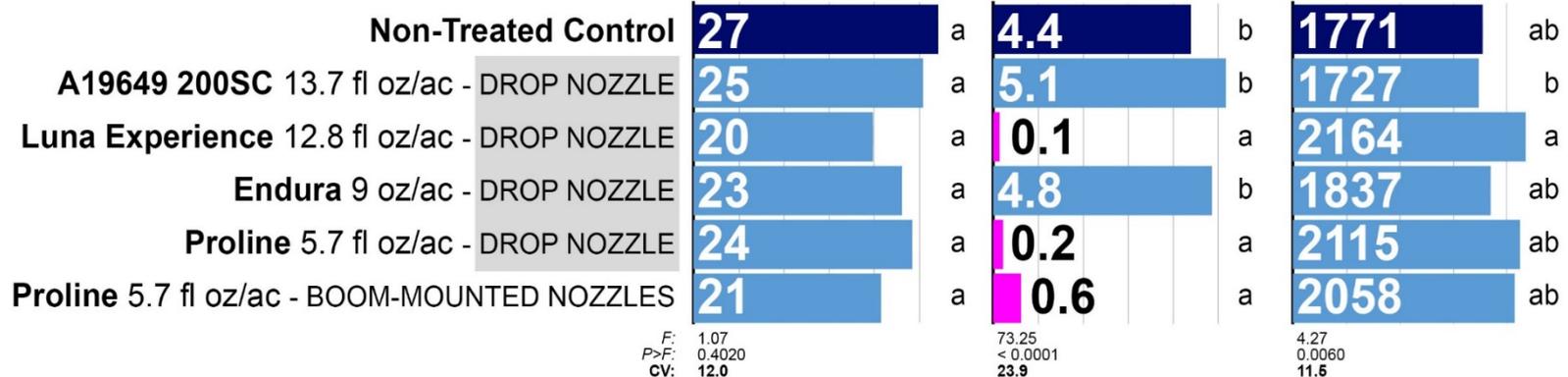
Sept. 25 | R7/R8 gr. stage

Sunflower Yield

10% moisture

pounds / acre

1. Sunflower heads inoculated with ascospores of *Sclerotinia sclerotiorum* 2 days after fungicides were applied



2. Sunflower heads inoculated with ascospores of *Sclerotinia sclerotiorum* 7 days after fungicides were applied



Fungicide Efficacy - 2017

Carrington, ND: sunflowers at average R5.9 growth stage

**Sclerotinia
Head Rot
Severity Index**

Percent of sunflower
head tissue diseased

Oct. 16 | R9 growth stage

**Rust
Severity**

Percent of leaf area
covered by rust pustules;
4th leaf from top of plant

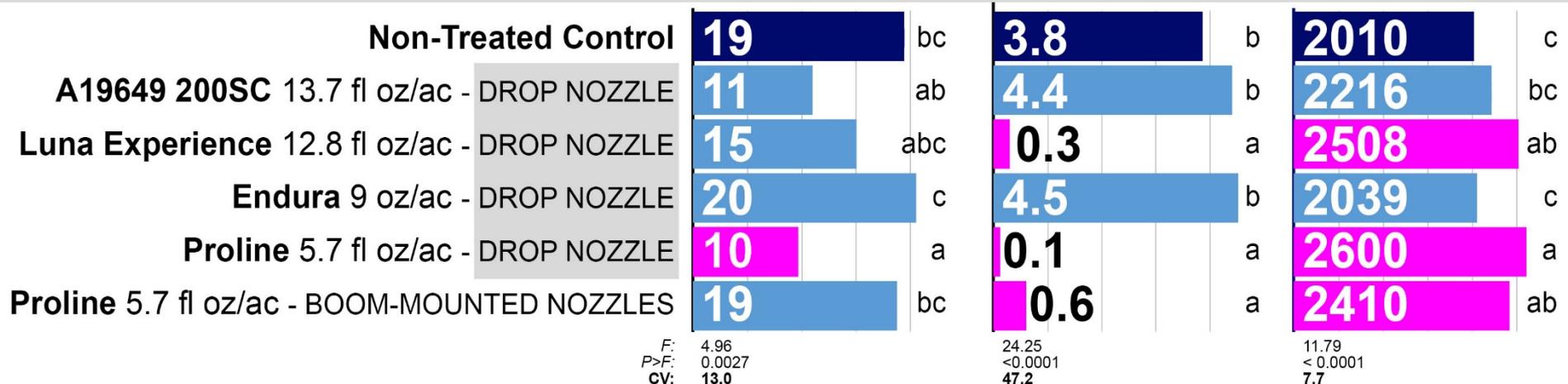
Sept. 25 | R7/R8 gr. stage

**Sunflower
Yield**

10% moisture

pounds / acre

Sunflower heads inoculated with ascospores of *Sclerotinia sclerotiorum* 1 day after fungicides were applied

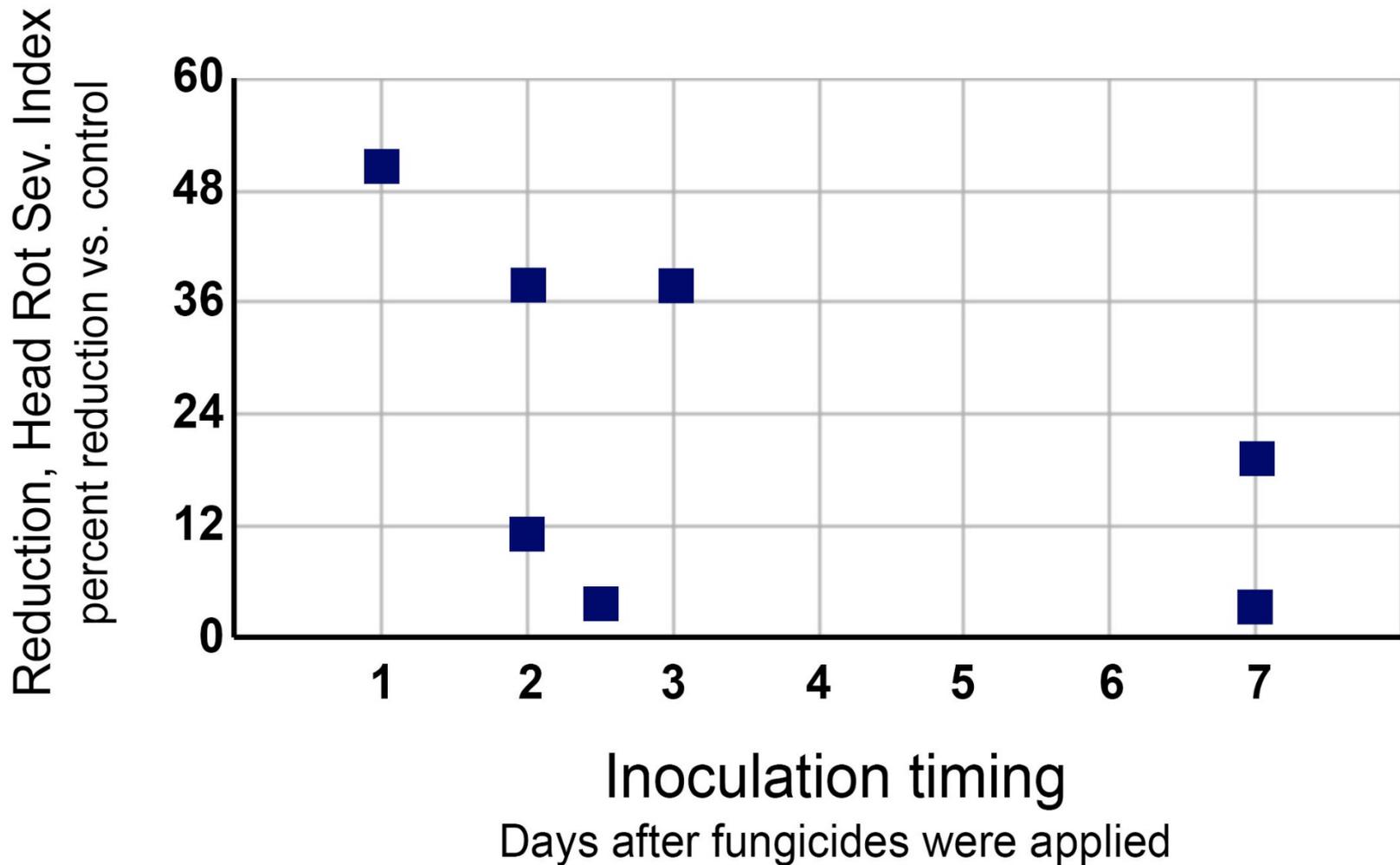


Spray nozzles, application pressure:

- Drop nozzle: XR11002 (flat-fan) nozzles, side ports; 40 psi
- Boom-mounted nozzles: XR11002 (flat-fan) nozzles; 40 psi

Fungicide Efficacy - 2017

Carrington, ND: sunflowers at average R5.9 growth stage



Spray nozzles, application pressure:

- XR11002 (flat-fan) nozzles, side ports of drop nozzle; 40 psi

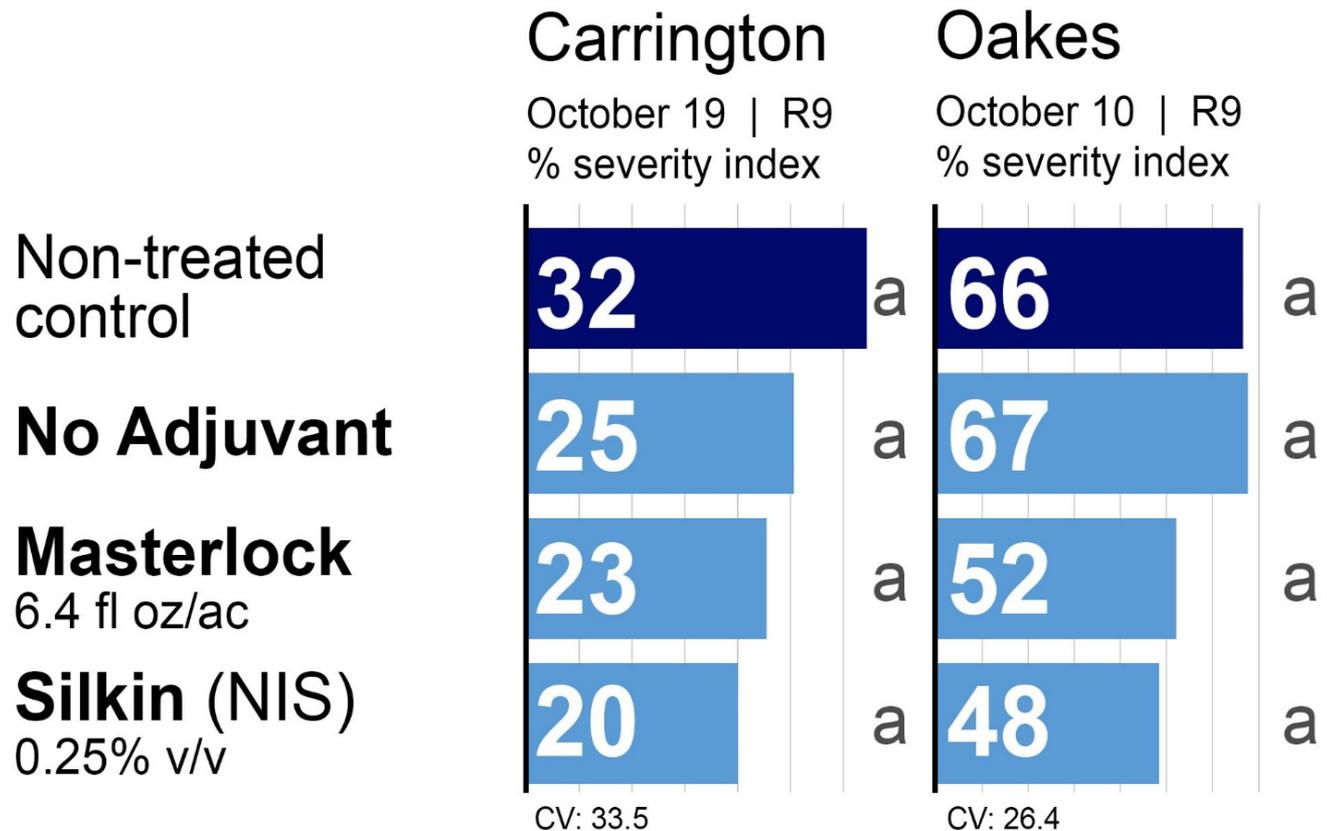
Fungicide:

Proline 480SC 5.7 fl oz/ac + Silkin (NIS) 0.25 % v/v

Impact of adjuvants - 2017

Sunflowers at average R5.4 growth stage (Oakes), R5.5 (Carrington)

Sclerotinia head rot:



Spray nozzles, application pressure:

- Carrington: XR11002 (flat-fan) nozzles, side ports of crop nozzle; 40 psi
- Oakes: XR11001 (flat-fan) nozzles, side ports of crop nozzle; 40 psi

Fungicide: Proline 480SC 5.7 fl oz/ac

Inoculated: 3 days after fungicides applied (Carrington)
2 and 3 days after fungicides applied (Oakes)

Impact of adjuvants – 2017

Sunflowers at average R5.4 growth stage (Oakes), R5.5 (Carrington)

Rust:

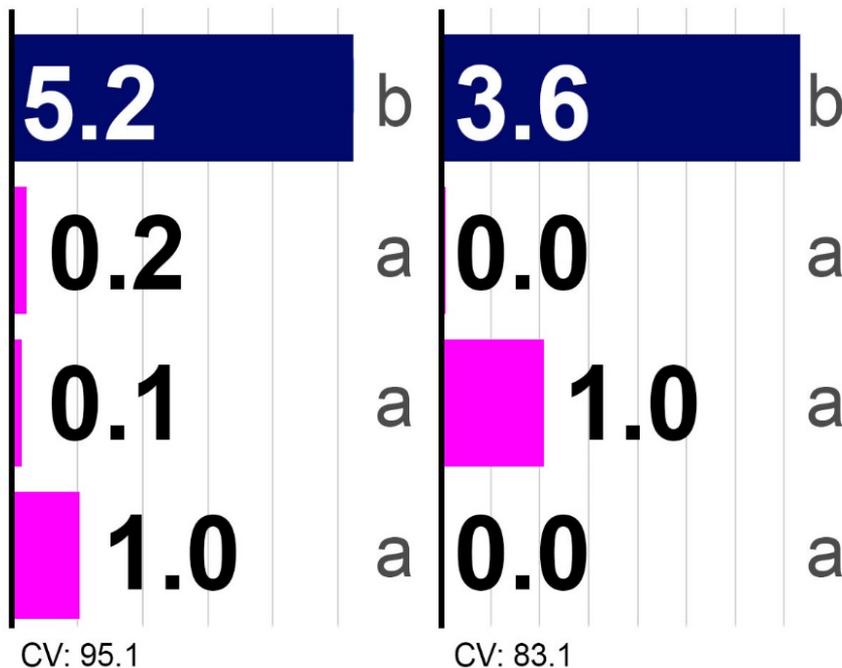
Carrington

Sept. 20 | R7
% severity

Oakes

Sept. 7 | R7
% severity

Non-treated control



Spray nozzles, application pressure:

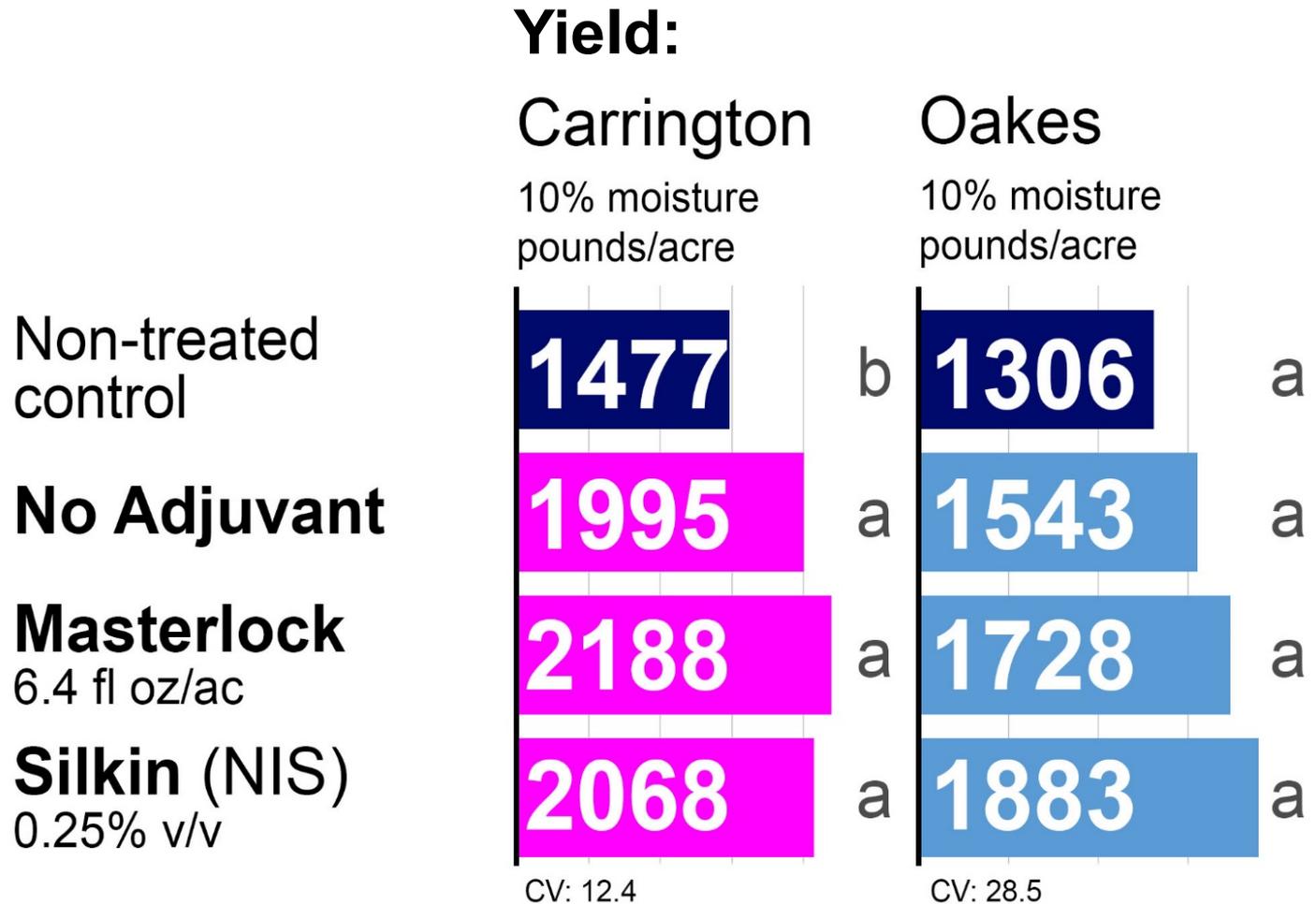
- Carrington: XR11002 (flat-fan) nozzles, side ports of crop nozzle; 40 psi
- Oakes: XR11001 (flat-fan) nozzles, side ports of crop nozzle; 40 psi

Fungicide: Proline 480SC 5.7 fl oz/ac

Inoculated: 3 days after fungicides applied (Carrington)
2 and 3 days after fungicides applied (Oakes)

Impact of adjuvants - 2017

Sunflowers at average R5.4 growth stage (Oakes), R5.5 (Carrington)



Spray nozzles, application pressure:

- Carrington: XR11002 (flat-fan) nozzles, side ports of crop nozzle; 40 psi
- Oakes: XR11001 (flat-fan) nozzles, side ports of crop nozzle; 40 psi

Fungicide: Proline 480SC 5.7 fl oz/ac

Inoculated: 3 days after fungicides applied (Carrington)
2 and 3 days after fungicides applied (Oakes)

Impact of application method - 2017

Sunflowers at average R5.4 growth stage (Oakes), R5.5 (Carrington)

Fungicide

Proline 480SC 5.7 fl oz/ac +
Silkin (NIS) 0.25% v/v

Inoculation

Carrington: 3 days after fungicide application
Oakes: 2 and 3 days after fungicide application

Sclerotinia head rot:

Carrington

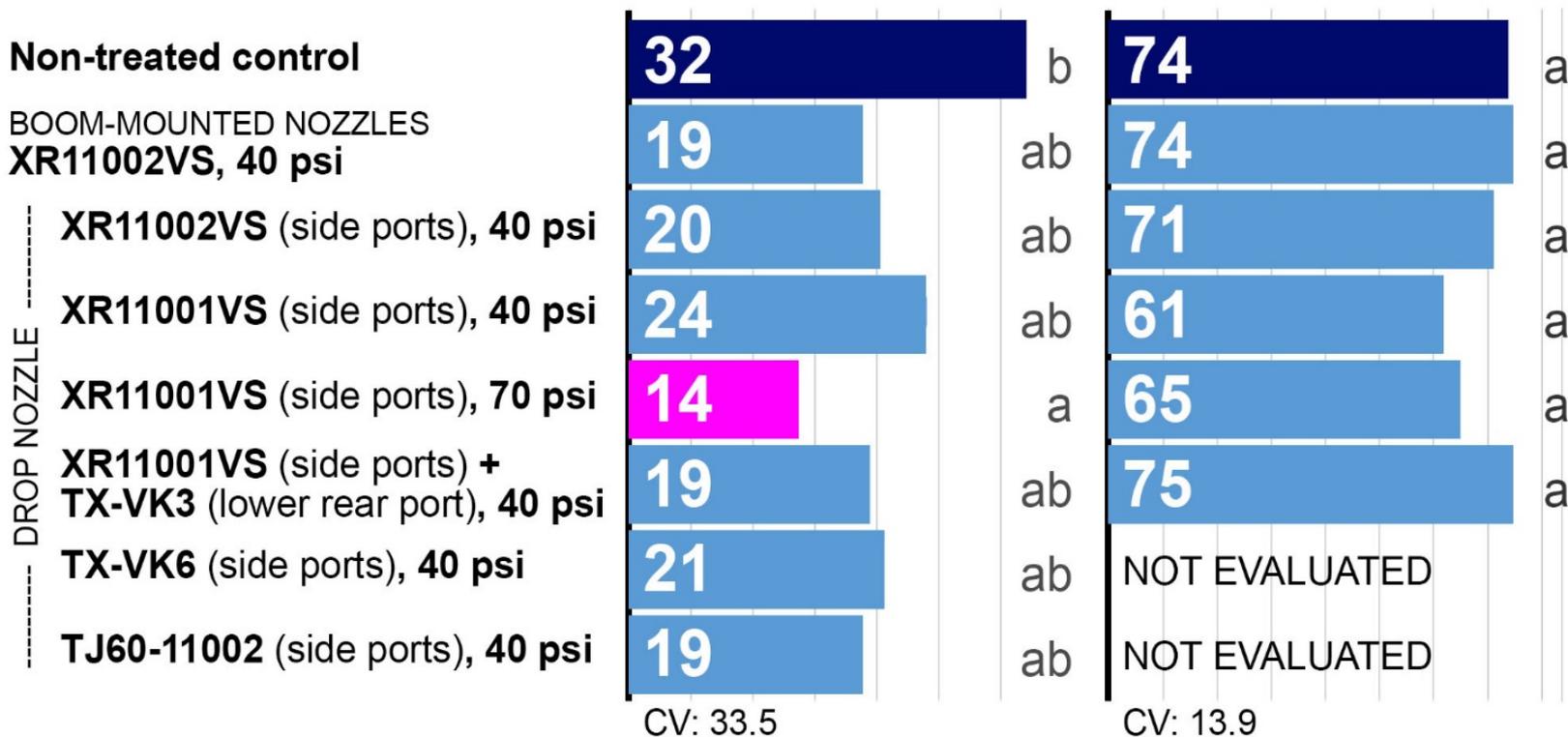
Oct. 19 | R9

% severity index

Oakes

Oct. 10 | R9

% severity index



Impact of application method - 2017

Sunflowers at average R5.4 growth stage (Oakes), R5.5 (Carrington)

Fungicide

Proline 480SC 5.7 fl oz/ac +
Silkin (NIS) 0.25% v/v

Inoculation

Carrington: 3 days after fungicide application
Oakes: 2 and 3 days after fungicide application

Rust:

Carrington

Sept. 20 | R7
% severity

Oakes

Sept. 7 | R7
% severity

Non-treated control

BOOM-MOUNTED NOZZLES

XR11002VS, 40 psi

XR11002VS (side ports), 40 psi

XR11001VS (side ports), 40 psi

XR11001VS (side ports), 70 psi

XR11001VS (side ports) +
TX-VK3 (lower rear port), 40 psi

TX-VK6 (side ports), 40 psi

TJ60-11002 (side ports), 40 psi

DROPP NOZZLE

5.2

0.6

1.0

0.7

0.1

0.1

0.1

0.1

CV: 95.1

b

3.45

a

0.21

a

0.02

a

0.02

a

0.16

a

0.06

a

NOT EVALUATED

a

NOT EVALUATED

CV: 69.2

b

a

a

a

a

a

Impact of application method - 2017

Sunflowers at average R5.4 growth stage (Oakes), R5.5 (Carrington)

Fungicide

Proline 480SC 5.7 fl oz/ac +
Silkin (NIS) 0.25% v/v

Inoculation

Carrington: 3 days after fungicide application
Oakes: 2 and 3 days after fungicide application

Yield:

Carrington

10% moisture
pounds/acre

Oakes

10% moisture
pounds/acre

Non-treated control

BOOM-MOUNTED NOZZLES XR11002VS, 40 psi

XR11002VS (side ports), 40 psi

XR11001VS (side ports), 40 psi

XR11001VS (side ports), 70 psi

XR11001VS (side ports) +
TX-VK3 (lower rear port), 40 psi

TX-VK6 (side ports), 40 psi

TJ60-11002 (side ports), 40 psi

----- DROP NOZZLE -----

1477

2235

2068

2223

2404

2251

2156

2193

CV: 12.4

b

1309

a

1281

a

1473

a

1564

a

1704

a

1220

a

NOT EVALUATED

a

NOT EVALUATED

CV: 23.3

a

a

a

a

a

a

Conclusions

Field trials conducted in 2017

- **Fungicide efficacy:**
 - Proline was best, but performance was inconsistent
- **Fungicide residual:**
 - Residual activity < 7 days with the fungicides tested
- **Adjuvants:**
 - Use of a NIS improves fungicide efficacy vs. head rot
- **Application methods:**
 - For applications via drop nozzles, flat-fan nozzles delivering very fine droplets may be optimal

Project Background - 2018

Managing Sclerotinia head rot with fungicides

To obtain rigorous results, large plots were utilized:

- Carrington: minimum 300 sq ft / plot
- Oakes: minimum 190 sq ft / plot



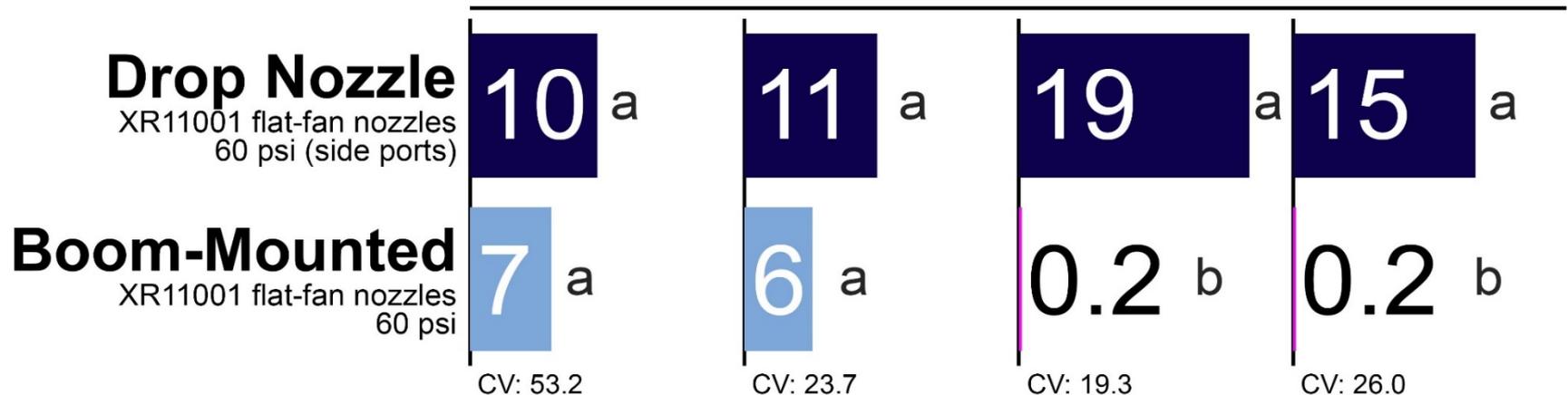
Fungicide application timing

Field trials conducted in 2018

Fungicide coverage conferred by boom-mounted nozzles strongly impacted by growth stage

	Carrington 2018	Carrington 2018	Oakes 2018	Carrington 2018
<i>Plants with open disk flowers:</i>	43%	79%	95%	100%
<i>Average growth stage:</i>	R5.0	R5.3	R5.6	R5.9
<i>Range of growth stages:</i>	R4-R5.4	R4-R5.8	R4-R5.9	R5.1-R6.0

FUNGICIDE COVERAGE (%)



Application timing – Carrington (2018):
 plants with open disk flowers = **43%**
 average growth stage = **R5.0**

Good fungicide coverage, poor disease control.

			Rust	Sclerotinia	Sclerotia	Yield
			R8 growth stage	R9 growth stage	in grain	10% moisture
			% severity	% incidence	% by weight	lbs/ac
Inoculated 1 day after fungicides applied						
1	Non-treated control		1.2 b*	47 a*	8 a*	2250 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	0.2 a	51 a	9 a	1826 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	0.3 a	52 a	8 a	2007 a
			CV: 24.9	CV: 15.7	CV: 16.1	CV: 18.5
Inoculated 4 days after fungicides applied						
1	Non-treated control		1.1 b*	70 a*	17 a*	1344 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	0.2 a	75 a	16 a	1165 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	0.3 a	75 a	17 a	1167 a
			CV: 28.2	CV: 7.0	CV: 43.6	CV: 51.8

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac

Drop nozzle: Driving speed = 2.4 mph Pressure = 60 psi Nozzles = TeeJet XR11001 flat-fan (side ports)

Boom-mounted: Driving speed = 3.2 mph Pressure = 60 psi Nozzles = TeeJet XR11001 flat-fan

Application timing - Carrington (2018):

plants with open disk flowers = **79%**, average growth stage = **R5.3**

Good fungicide coverage, poor disease control.

			Rust R8 growth stage % severity	Sclerotinia head rot R9 growth stage % incidence	Sclerotia contamination in grain % by weight	Yield 10% moisture lbs/ac
Inoculated 1 day after fungicides applied						
1	Non-treated control		0.68 b*	3 a*	0.7 a*	3487 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	0.01 a	3 a	0.4 a	3611 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	0.01 a	2 a	0.2 a	3266 a
			CV: 110.1	CV: 60.7	CV: 101.8	CV: 19.9
Inoculated 3 days after fungicides applied						
1	Non-treated control		0.38 b*	41 a*	8.7 a*	2325 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	0.01 a	51 a	11.2 a	2030 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	0.01 a	40 a	7.9 a	2267 a
			CV: 135.3	CV: 29.5	CV: 40.3	CV: 27.7
Inoculated 7 days after fungicides applied						
1	Non-treated control		0.40 b*	23 a*	3.3 a*	3430 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	0.01 a	22 a	2.3 a	3010 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	0.02 a	23 a	2.8 a	3028 a
			CV: 116.3	CV: 42.4	CV: 60.9	CV: 16.8

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Drop nozzle:** Driving speed = 2.4 mph Pressure = 60 psi Nozzles = TeeJet XR11001 flat-fan (side ports)

Boom-mounted: Driving speed = 3.2 mph Pressure = 60 psi Nozzles = TeeJet XR11001 flat-fan

Application timing – Oakes (2018):
plants with open disk flowers = **95%**, average growth stage = **R5.6**

			Sclerotinia head rot	Sclerotia contamination	Yield
			R9 growth stage % incidence	in grain % by weight	10% moisture lbs/ac
Inoculated 1 day after fungicides applied					
1	Non-treated control		66 ab*	7 a*	1403 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	76 b	8 a	1288 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	61 a	7 a	1398 a
			CV: 8.9	CV: 20.8	CV: 17.7
Inoculated 3 days after fungicides applied					
1	Non-treated control		65 a*	7 a*	1592 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	63 a	8 a	1622 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	57 a	6 a	1913 a
			CV: 8.9	CV: 25.4	CV: 10.6
Inoculated 5 days after fungicides applied					
1	Non-treated control		32 a*	3 a*	2258 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	37 a	4 a	2293 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	26 a	3 a	2488 a
			CV: 28.1	CV: 32.5	CV: 11.5

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Drop nozzle:** Driving speed = 2.4 mph Pressure = 60 psi Nozzles = XR11001 (side ports)

Boom-mounted: Driving speed = 3.2 mph Pressure = 60 psi Nozzles = TeeJet XR11001

Application timing – Carrington (2018):

plants with open disk flowers = **100%**

average growth stage = **R5.9**

Good fungicide coverage with drop nozzles,
poor disease control.

			Rust	Sclerotinia head rot	Sclerotia contamination	Yield
			R8 growth stage	R9 growth stage	in grain	10% moisture
			% severity	% incidence	% by weight	lbs/ac
Inoculated 2 days after fungicides applied						
1	Non-treated control		1.7 b*	67 a*	9 a*	1636 a*
2	Proline 5.7 fl oz + Silkin 0.25% v/v	Boom	0.2 a	67 a	8 a	1637 a
3	Proline 5.7 fl oz + Silkin 0.25% v/v	Drop nozzle	0.1 a	67 a	9 a	1599 a
			CV: 48.8	CV: 7.7	CV: 26.1	CV: 14.9

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac

Drop nozzle: Driving speed = 2.4 mph Pressure = 60 psi Nozzles = TeeJet XR11001 flat-fan (side ports)

Boom-mounted: Driving speed = 3.2 mph Pressure = 60 psi Nozzles = TeeJet XR11001 flat-fan

Optimizing boom-mounted nozzles

Field trials conducted in 2018

Modifying droplet size, adjuvants, or driving direction did not improve fungicide coverage

				Carrington	Oakes
<i>percent of plants with open disk flowers:</i>				87%	95%
<i>average growth stage:</i>				R5.4	R5.6
<i>range of growth stages:</i>				R4-R5.8	R4-R5.9
1 Non-treated control					
2	XR11001 , 60 psi; very fine droplets	east	Silkin 0.25% v/v	7 a*	4 a*
3	XR11002 , 40 psi; fine droplets	east	Silkin 0.25% v/v	7 a	7 a
4	XR11004 , 35 psi; medium droplets	east	Silkin 0.25% v/v	7 a	4 a
5	XR11001 , 60 psi; very fine droplets	west	Silkin 0.25% v/v	8 a	Not tested
6	XR11001 , 60 psi; very fine droplets	east	Preference 0.25% v/v	No Data	Not tested
7	XR11001 , 60 psi; very fine droplets	east	no adjuvant	No Data	No Data
				CV: 33.2	CV: 20.9

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Driving speed:** 3.2 mph

Calibrated pulse widths: Trt. 2, 5, 6, 7 (XR11001) = 100%, Trt. 3 (XR11002) = 40%, Trt. 4 (XR11004) = 26%

Optimizing boom-mounted nozzles

Carrington (2018)

Modifying droplet size, adjuvants, or driving direction did not improve *Sclerotinia* head rot control.

				Rust	Sclerotinia head rot
				R8 growth stage	R9 growth stage
				% severity	% incidence
1	Non-treated control			1.25 b*	86 a*
2	XR11001, 60 psi; very fine droplets	east	Silkin 0.25% v/v	0.05 a	89 a
3	XR11002, 40 psi; fine droplets	east	Silkin 0.25% v/v	0.04 a	87 a
4	XR11004, 35 psi; medium droplets	east	Silkin 0.25% v/v	0.04 a	88 a
5	XR11001, 60 psi; very fine droplets	west	Silkin 0.25% v/v	0.04 a	92 a
6	XR11001, 60 psi; very fine droplets	east	Preference 0.25% v/v	0.10 a	87 a
7	XR11001, 60 psi; very fine droplets	east	no adjuvant	0.14 a	86 a
				CV: 62.4	CV: 6.5

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Driving speed:** 3.2 mph

Calibrated pulse widths: Trt. 2, 5, 6, 7 (XR11001) = 100%, Trt. 3 (XR11002) = 40%, Trt. 4 (XR11004) = 26%

Optimizing boom-mounted nozzles

Oakes (2018)

Modifying droplet size or adjuvants did not improve *Sclerotinia* head rot control or yield.

			Sclerotinia head rot	Yield
			R9 growth stage % incidence	10% moisture pounds/acre
1 Non-treated control			84 a*	2038 a*
2 XR11001 , 60 psi; very fine droplets	east	Silkin 0.25% v/v	88 a	1609 a
3 XR11002 , 40 psi; fine droplets	east	Silkin 0.25% v/v	88 a	1562 a
4 XR11004 , 35 psi; medium droplets	east	Silkin 0.25% v/v	84 a	1552 a
5 XR11001 , 60 psi; very fine droplets	east	no adjuvant	89 a	1962 a
			CV: 3.9	CV: 23.2

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Driving speed:** 3.2 mph

Calibrated pulse widths: Treat,ents 2, 5 (XR11001) = 100%, Trt. 3 (XR11002) = 40%, Trt. 4 (XR11004) = 26%

Optimizing applications with drop nozzles

Field trials conducted in 2018

Modifying droplet size, adjuvants, or driving direction did not improve fungicide coverage

	Carrington	Oakes
<i>percent of plants with open disk flowers:</i>	89%	95%
<i>average growth stage:</i>	R5.5	R5.6
<i>range of growth stages:</i>	R4-R5.8	R4-R5.9

1 Non-treated control

2 XR11001, 60 psi; very fine droplets	east	Silkin 0.25% v/v	21 a*	15 a*
3 XR11002, 50 psi; fine droplets	east	Silkin 0.25% v/v	15 a	15 a
4 XR11003, 40 psi; fine droplets	east	Silkin 0.25% v/v	18 a	11 a
5 XR11004, 30 psi; medium droplets	east	Silkin 0.25% v/v	24 a	21 a
6 XR11001, 60 psi; very fine droplets	west	Silkin 0.25% v/v	17 a	18 a
7 XR11001, 60 psi; very fine droplets	east	Preference 0.25% v/v	No Data	Not tested
8 XR11001, 60 psi; very fine droplets	east	no adjuvant	No Data	No Data
			CV: 45.4	CV: 52.3

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Driving speed:** 2.4 mph

Calibrated pulse widths:

Trt. 2, 6, 7, 8 (XR11001) = 100%, Trt. 3 (XR11002) = 40%, Trt. 4 (XR11003) = 33%, Trt. 5 (XR11004) = 26%

Optimizing applications with drop nozzles

Carrington (2018)

Modifying droplet size, adjuvants, or driving direction did not improve *Sclerotinia* head rot control.

			Rust	Sclerotinia	
			R8 growth stage	R9 growth stage	
			% severity	% incidence	
1	Non-treated control		1.58 b*	85 a*	
2	XR11001 , 60 psi; very fine droplets	east	Silkin 0.25% v/v	0.05 a	88 a
3	XR11002 , 50 psi; fine droplets	east	Silkin 0.25% v/v	0.03 a	79 a
4	XR11003 , 40 psi; fine droplets	east	Silkin 0.25% v/v	0.13 a	88 a
5	XR11004 , 30 psi; medium droplets	east	Silkin 0.25% v/v	0.05 a	87 a
6	XR11001 , 60 psi; very fine droplets	west	Silkin 0.25% v/v	0.17 a	85 a
7	XR11001 , 60 psi; very fine droplets	east	Preference 0.25% v/v	0.04 a	84 a
8	XR11001 , 60 psi; very fine droplets	east	no adjuvant	0.16 a	80 a
			CV: 115.2	CV: 8.5	

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Driving speed:** 2.4 mph

Calibrated pulse widths:

Trt. 2, 6, 7, 8 (XR11001) = 100%, Trt. 3 (XR11002) = 40%, Trt. 4 (XR11003) = 33%, Trt. 5 (XR11004) = 26%

Optimizing applications with drop nozzles

Oakes (2018)

Modifying droplet size, adjuvants, or driving direction did not improve *Sclerotinia* head rot control or yield.

			Sclerotinia head rot	Yield
			R9 growth stage % incidence	10% moisture pounds/acre
1 Non-treated control			80 a*	1840 a*
2 XR11001 , 60 psi; very fine droplets	east	Silkin 0.25% v/v	75 a	1920 a
3 XR11002 , 50 psi; fine droplets	east	Silkin 0.25% v/v	77 a	1916 a
4 XR11003 , 40 psi; fine droplets	east	Silkin 0.25% v/v	75 a	1841 a
5 XR11004 , 30 psi; medium droplets	east	Silkin 0.25% v/v	73 a	1833 a
6 XR11001 , 60 psi; very fine droplets	west	Silkin 0.25% v/v	80 a	1680 a
7 XR11001 , 60 psi; very fine droplets	east	no adjuvant	79 a	1902 a
			CV: 7.8	CV: 16.2

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Driving speed:** 2.4 mph

Calibrated pulse widths:

Trt. 2, 6, 7, 8 (XR11001) = 100%, Trt. 3 (XR11002) = 40%, Trt. 4 (XR11003) = 33%, Trt. 5 (XR11004) = 26%

Fungicide efficacy

Carrington (2018)

None of the other fungicides evaluated improved Sclerotinia head rot control.

	Rust	Sclerotinia head rot
	R8 growth stage	R9 growth stage
	% severity	% incidence
1 Non-treated	6.1 c*	88 a*
2 CR-7 75.71 g/ac	5.2 c	89 a
3 CR-7 113.56 g/ac	4.7 bd	90 a
4 Headline 250SC 6.0 fl oz/ac + Silkin 0.25% v/v	0.9 ab	87 a
5 Proline 480SC 5.7 fl oz/ac + Silkin 0.25% v/v	0.6 a	84 a
6 Priaxor 500SC 4.0 fl oz/ac + Silkin 0.25% v/v	1.5 abc	86 a
7 Endura 70WG 8.0 oz/ac + Silkin 0.25% v/v	4.0 abc	84 a
	CV: 40.3	CV: 6.2

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Spray volume: 15 gal/ac **Driving speed:** 2.4 mph

Fungicides applied with drop nozzles: Pressure = 60 psi Nozzles = TeeJet XR11001 flat-fan (side ports)

COMBINED ANALYSIS

Across all years

How have fungicides performed across all years?
Analysis conducted relative to disease pressure, application method, and application timing.

Fungicide efficacy

Endura
9 oz/ac



Study locations (years):

Carrington (2012, 2013, 2015)

Oakes (2013)

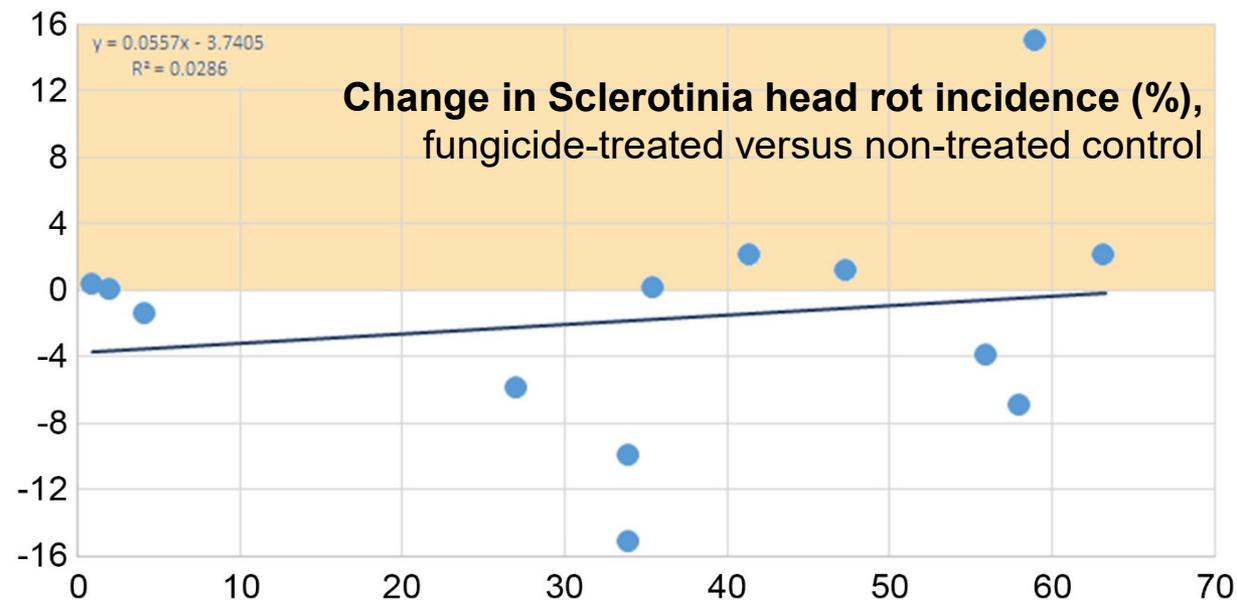
Langdon (2013)

Spray volume: 10, 15 or 20 gal/ac

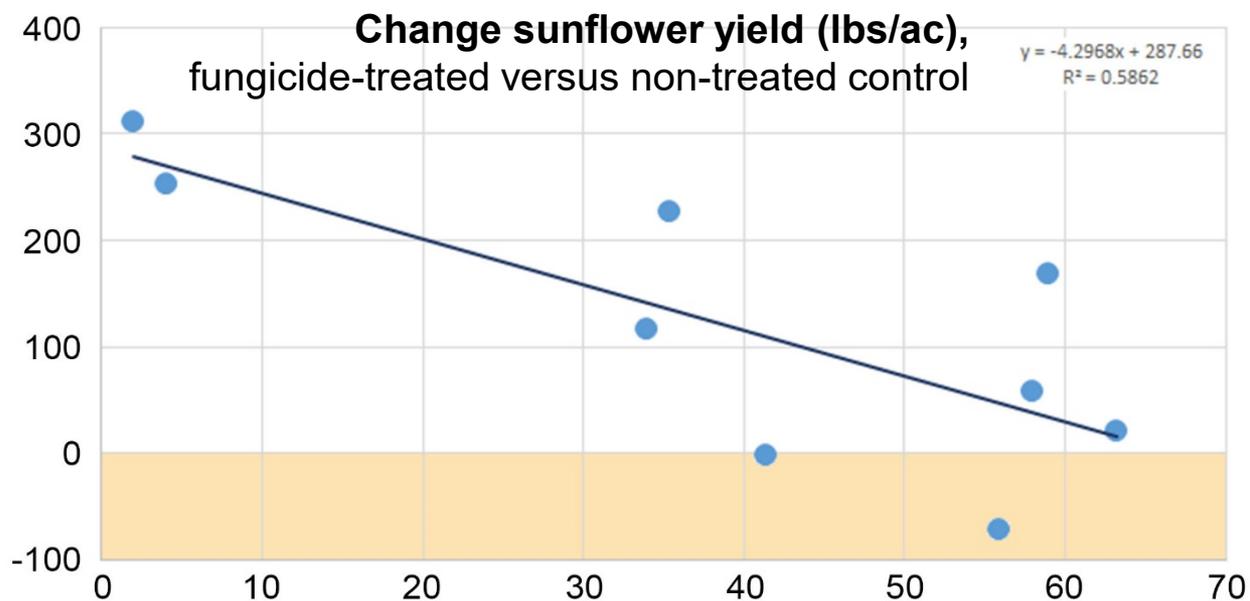
Spray nozzles, pressure: flat-fan nozzles, fine to medium droplet size. XR8001, 35 psi; R8002, 30 psi; XR8004, 55 psi; or TT11001, 40 psi

Application method: tractor-mounted boom (11 studies), hand-boom (2 studies)

Change in Disease (%)
conferred by the fungicide



Change in Yield (lbs/ac)
conferred by the fungicide



Sclerotinia head rot disease pressure (%)
Sclerotinia head rot in the non-treated control

Fungicide efficacy

Proline

5.7 fl oz/ac



Study locations (years):

Carrington (2017, 2018)

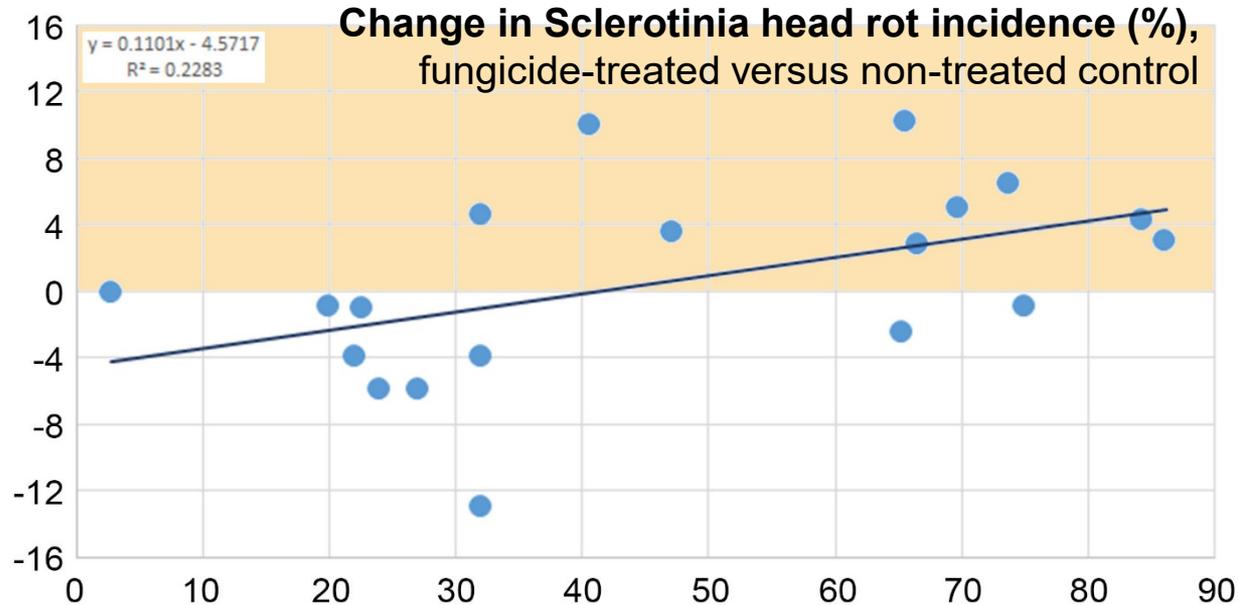
Oakes (2017, 2018)

Spray volume: 15 gal/ac

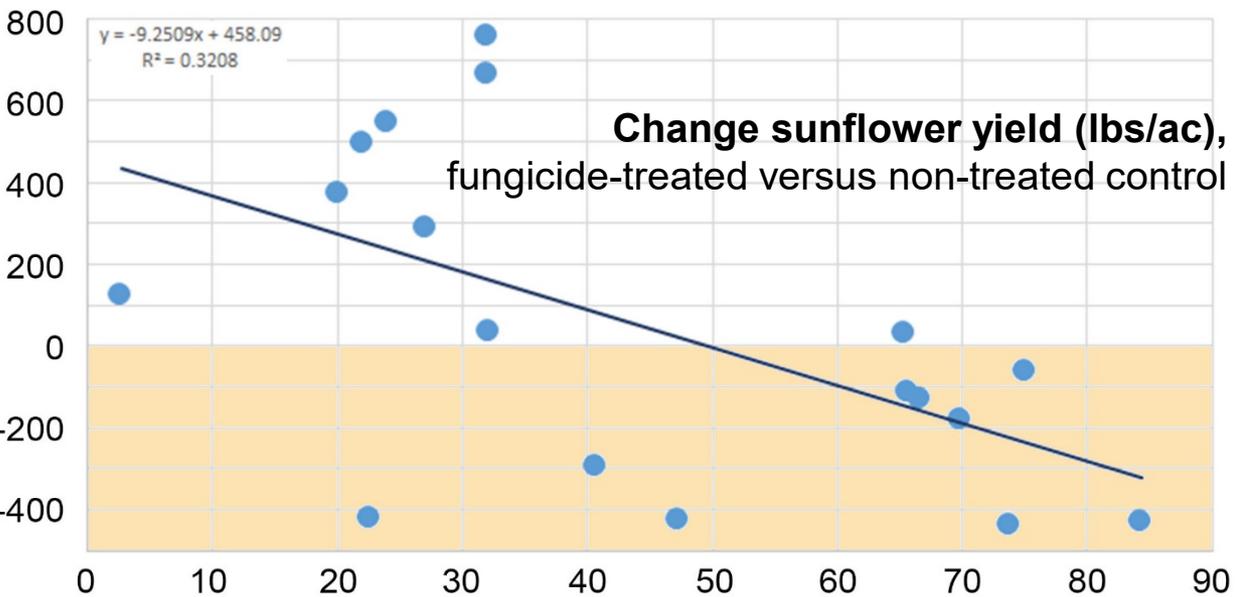
Spray nozzles, pressure: flat-fan nozzles, very fine to fine droplet size. XR11001, 60 psi or XR11002, 40 psi

Application method: tractor-mounted boom (all studies)

Change in Disease (%)
conferred by the fungicide



Change in Yield (lbs/ac)
conferred by the fungicide



Sclerotinia head rot disease pressure (%)
Sclerotinia head rot in the non-treated control

Fungicide efficacy

Endura
9 oz/ac



Study locations (years):

Carrington (2012, 2013, 2015)

Oakes (2013)

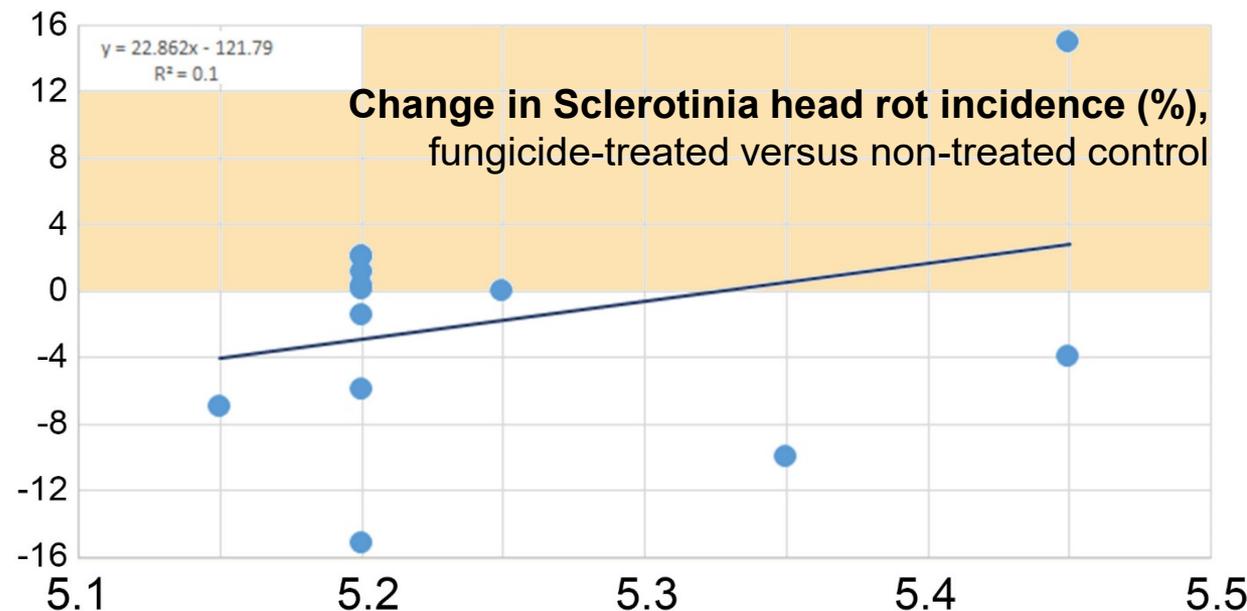
Langdon (2013)

Spray volume: 10, 15 or 20 gal/ac

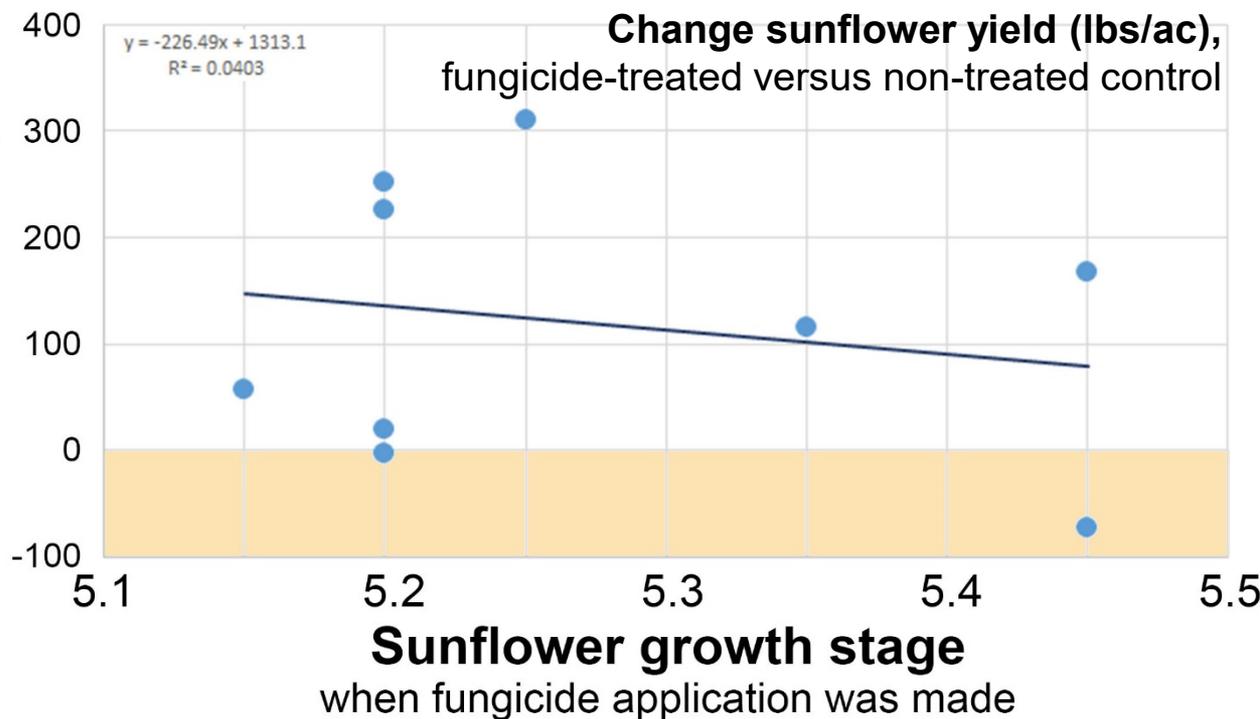
Spray nozzles, pressure: flat-fan nozzles, fine to medium droplet size. XR8001, 35 psi; R8002, 30 psi; XR8004, 55 psi; or TT11001, 40 psi

Application method: tractor-mounted boom (11 studies), hand-boom (2 studies)

Change in Disease (%)
conferred by the fungicide



Change in Yield (lbs/ac)
conferred by the fungicide



Fungicide efficacy

Proline

5.7 fl oz/ac



Study locations (years):

Carrington (2017, 2018)

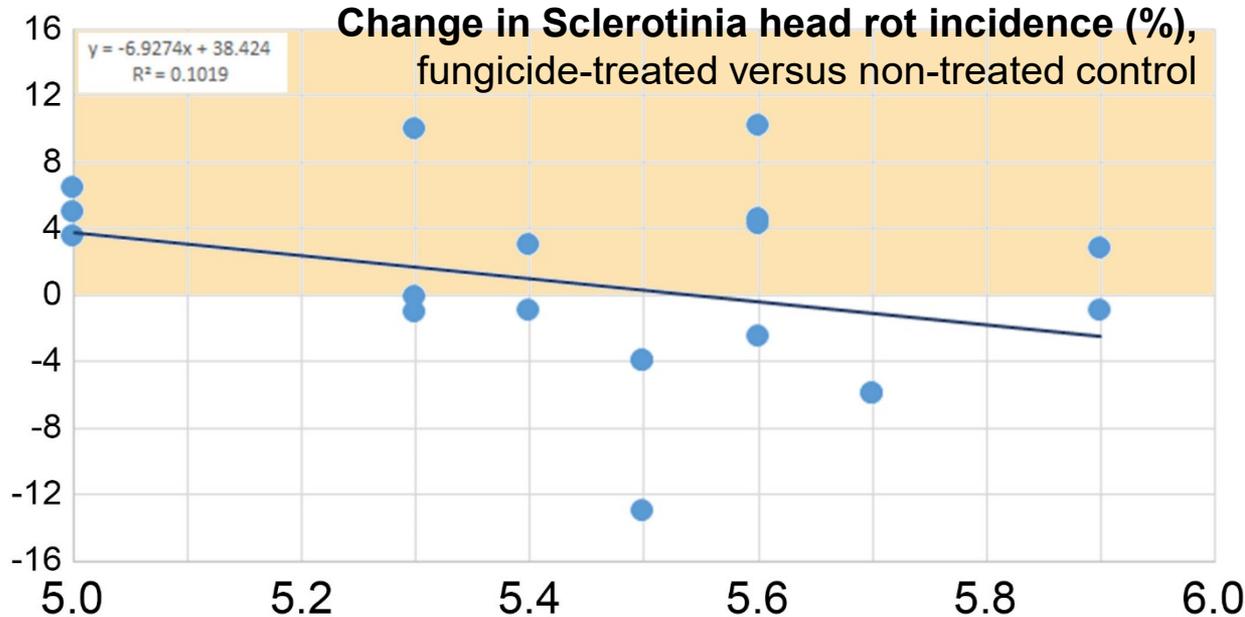
Oakes (2017, 2018)

Spray volume: 15 gal/ac

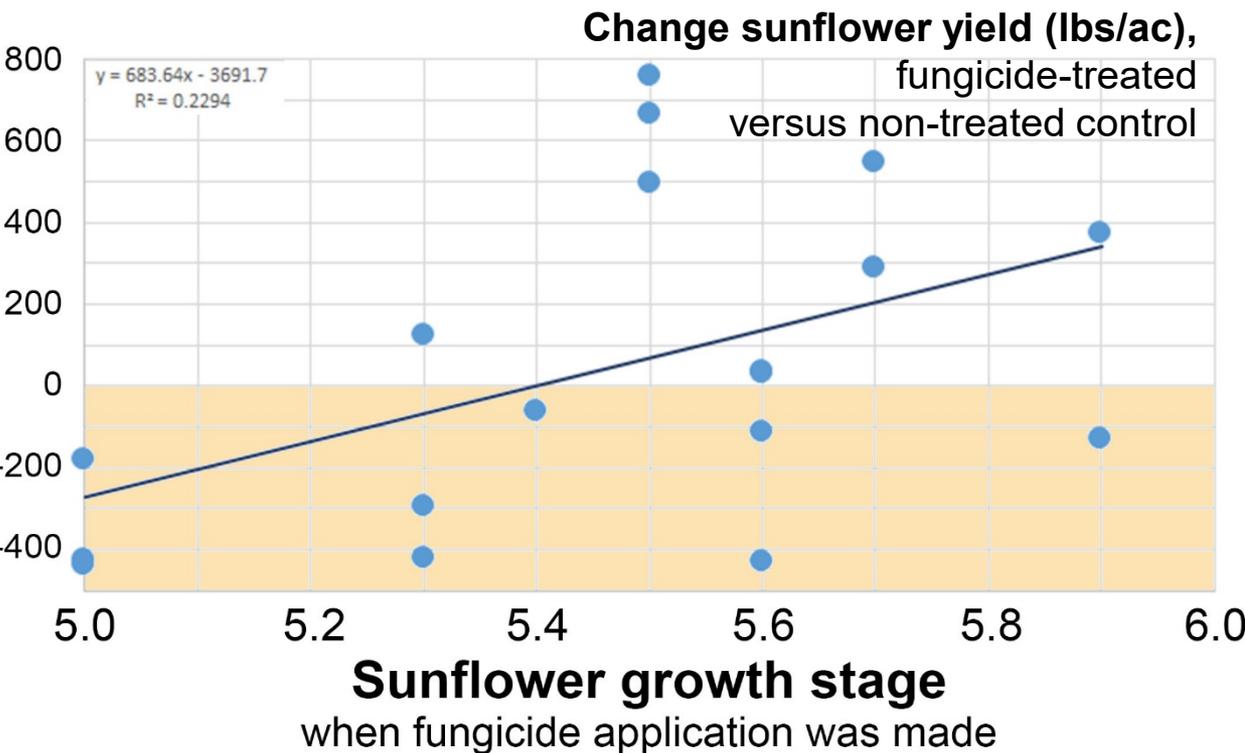
Spray nozzles, pressure: flat-fan nozzles, very fine to fine droplet size. XR11001, 60 psi or XR11002, 40 psi

Application method: tractor-mounted boom (all studies)

Change in Disease (%)
conferred by the fungicide



Change in Yield (lbs/ac)
conferred by the fungicide



Fungicide efficacy – drop nozzles

Endura
9 oz/ac



Study locations (years):

Carrington (2015, 2017)

Oakes (2017)

Spray volume: 15 gal/ac

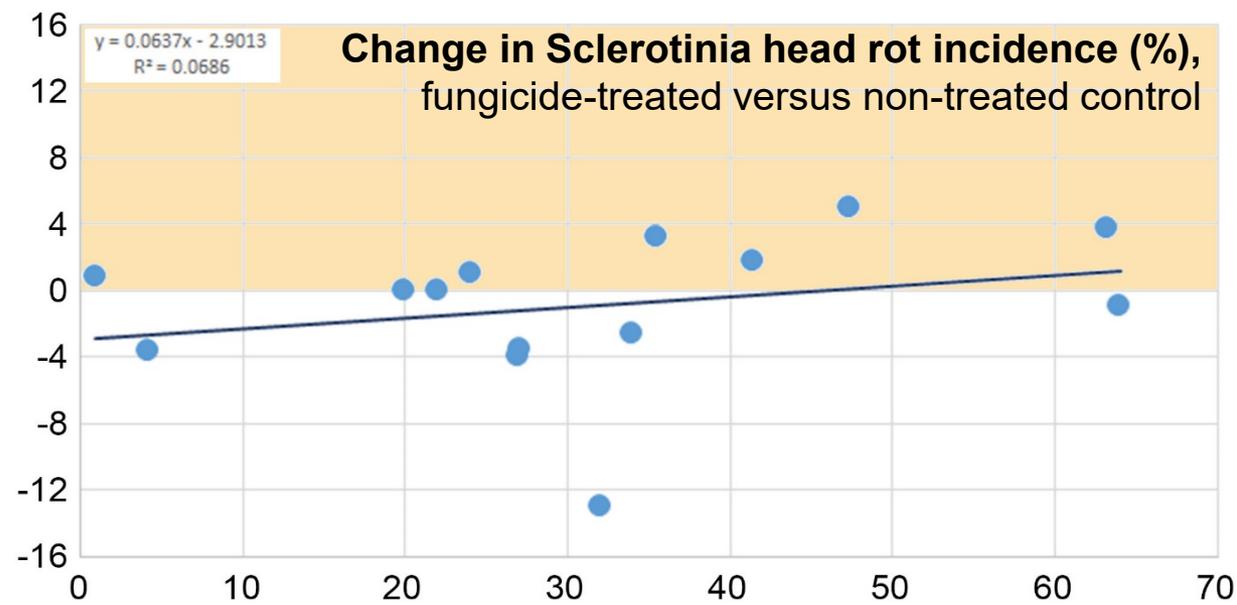
Spray nozzles, pressure: flat-fan
nozzles on side ports, fine droplet size.

XR11001, 40 psi

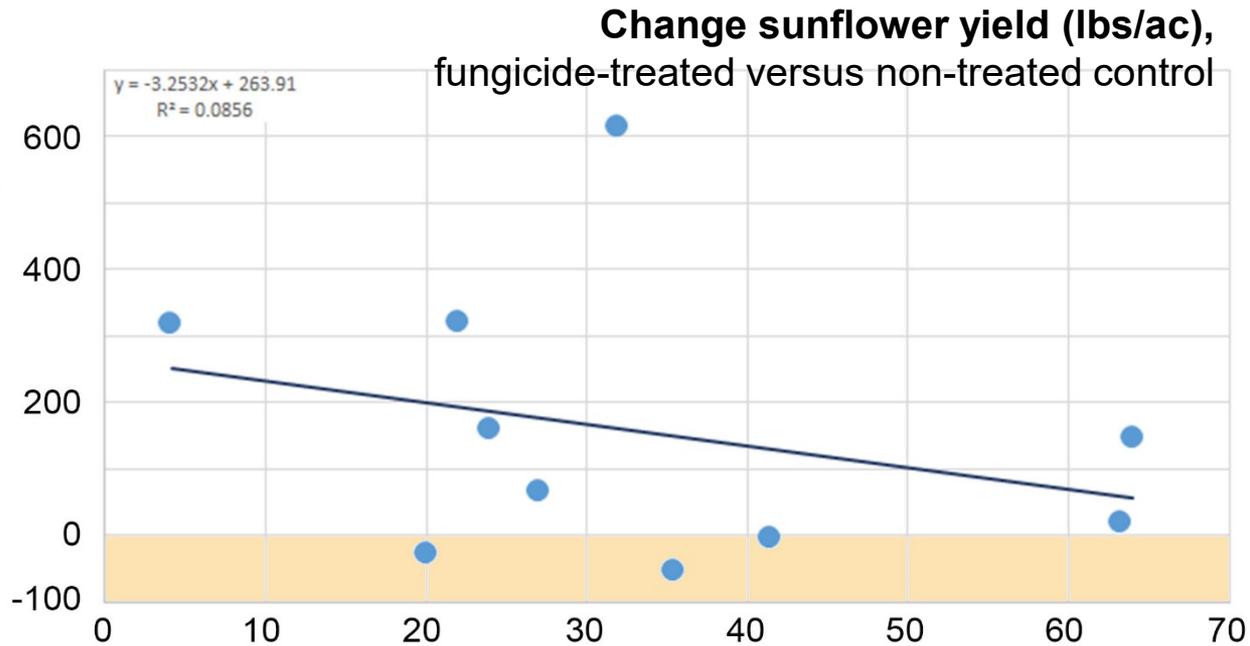
XR11002, 40 psi

Application method: tractor-mounted
boom equipped with '360 Undercover'
drop nozzles

Change in Disease (%)
conferred by the fungicide



Change in Yield (lbs/ac)
conferred by the fungicide



Sclerotinia head rot disease pressure (%)
Sclerotinia head rot in the non-treated control

Fungicide efficacy – drop nozzles

Proline
5.7 fl oz/ac



Study locations (years):

Carrington (2017, 2018)

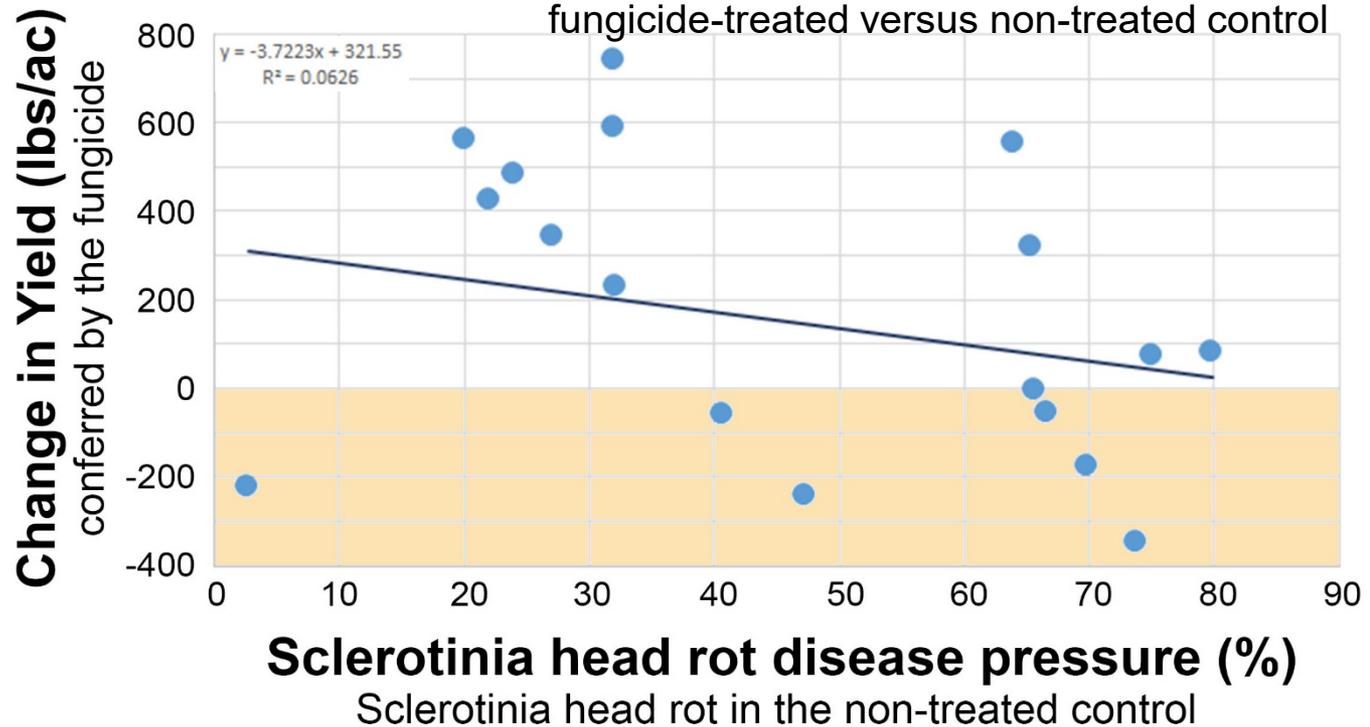
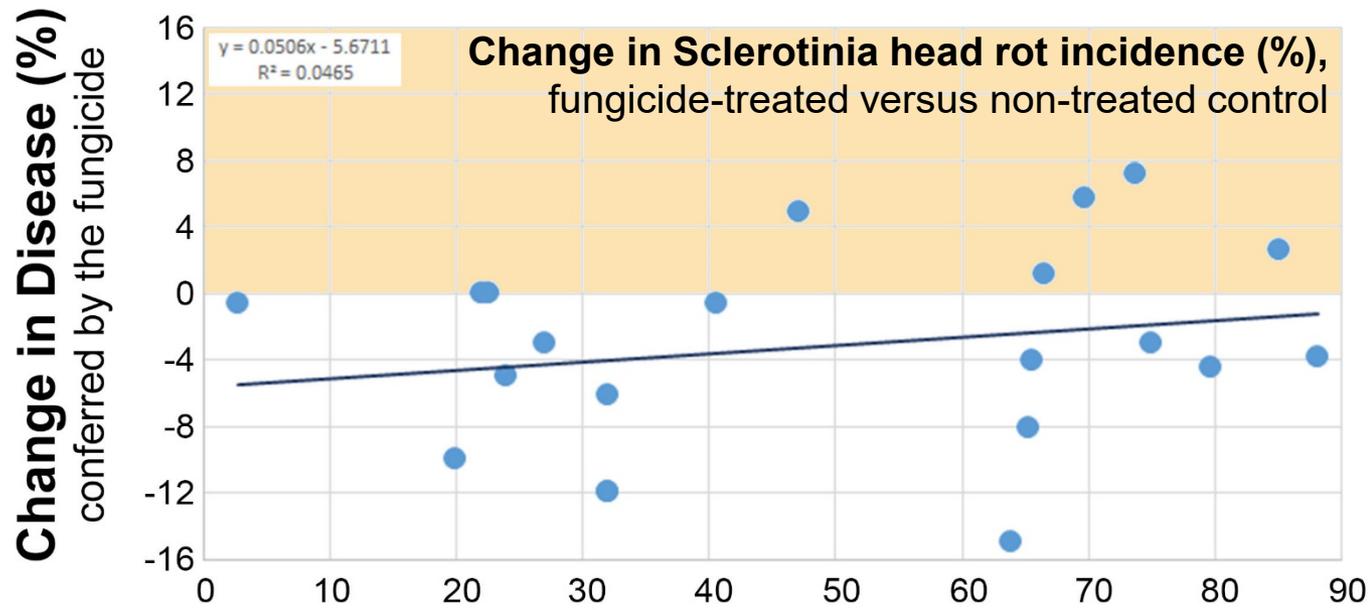
Oakes (2017, 2018)

Spray volume: 15 gal/ac

Spray nozzles, pressure: flat-fan nozzles on side ports, fine or very fine droplet size.

XR11001, 60 psi or XR11002, 40 psi

Application method: tractor-mounted boom equipped with '360 Undercover' drop nozzles



Conclusions

Multi-year, multi-location field trials

Field trials conducted from 2012-2018:

- None of the fungicides tested have provided consistent control of Sclerotinia head rot.
- Sclerotinia head rot control has been unsatisfactory irrespective of adjuvant use, fungicide application method, and fungicide application timing.
- Yield gains associated with fungicide applications targeting Sclerotinia head rot have been primarily due to management of off-target diseases (rust, Phoma, Phomopsis, etc.)

Thank you!



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