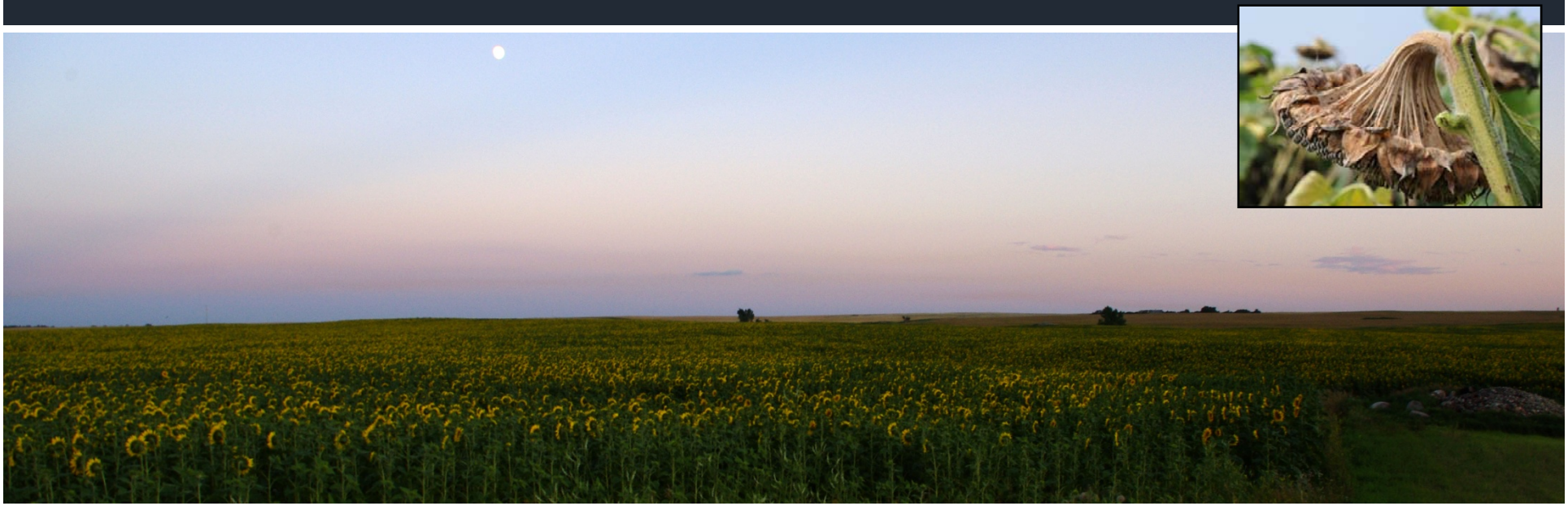
Obstacles to Managing Sclerotinia Head Rot of Sunflowers with Fungicides: Conclusions from Multi-Year Fungicide Application Technology Studies



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Project Background

Managing Sclerotinia head rot with fungicides

Objectives:

- Optimize fungicide application timing
- Identify the most effective fungicides and adjuvants
- Optimize applications with boom-mounted nozzles
- Optimize applications with drop nozzles

Fungicide applications:

tractor-mounted boom equipped with pulse-width modulation system from Capstan AG

Project Background

Managing Sclerotinia head rot with fungicides

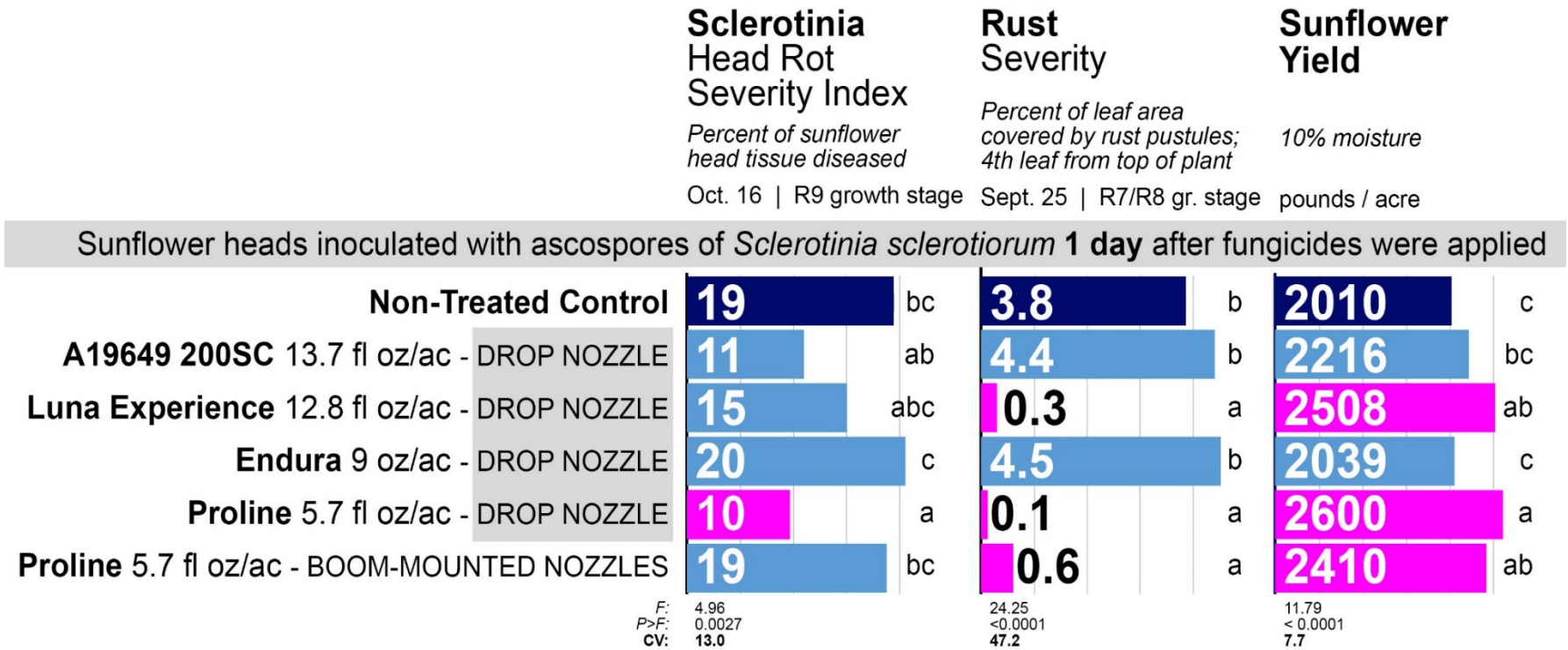
To obtain rigorous results, large plots were utilized:

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

Fungicide efficacy

Carrington, ND (2017)

Proline was the most effective fungicide evaluated.

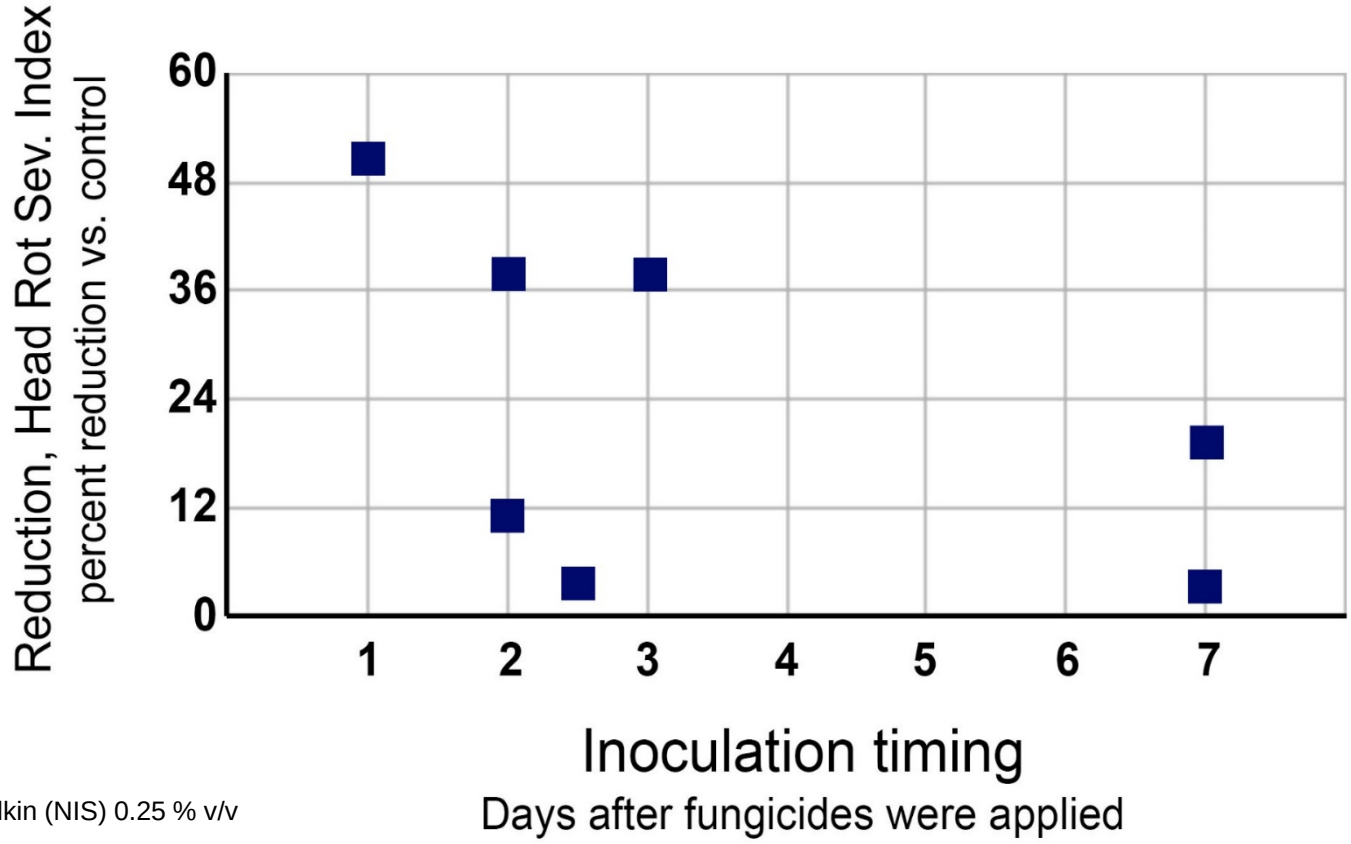


Spray volume: 15 gal/ac **Driving speed:** 2.6 mph
Spray nozzles, pressure: Boom-mounted: TeeJet XR11002 (flat-fan), 40 psi Drop nozzles: TeeJet XR11002 (flat-fan), side ports, 40 psi
Drop nozzles: 360 Undercover (360 Yield Center; Morton, IL)
Nozzle placement: Boom-mounted nozzles: boom set 20" above canopy Drop nozzles: nozzles centered on mid-point of heads

Fungicide efficacy

Carrington and Oakes, ND (2017)

… but fungicide residual activity appeared to be limited.



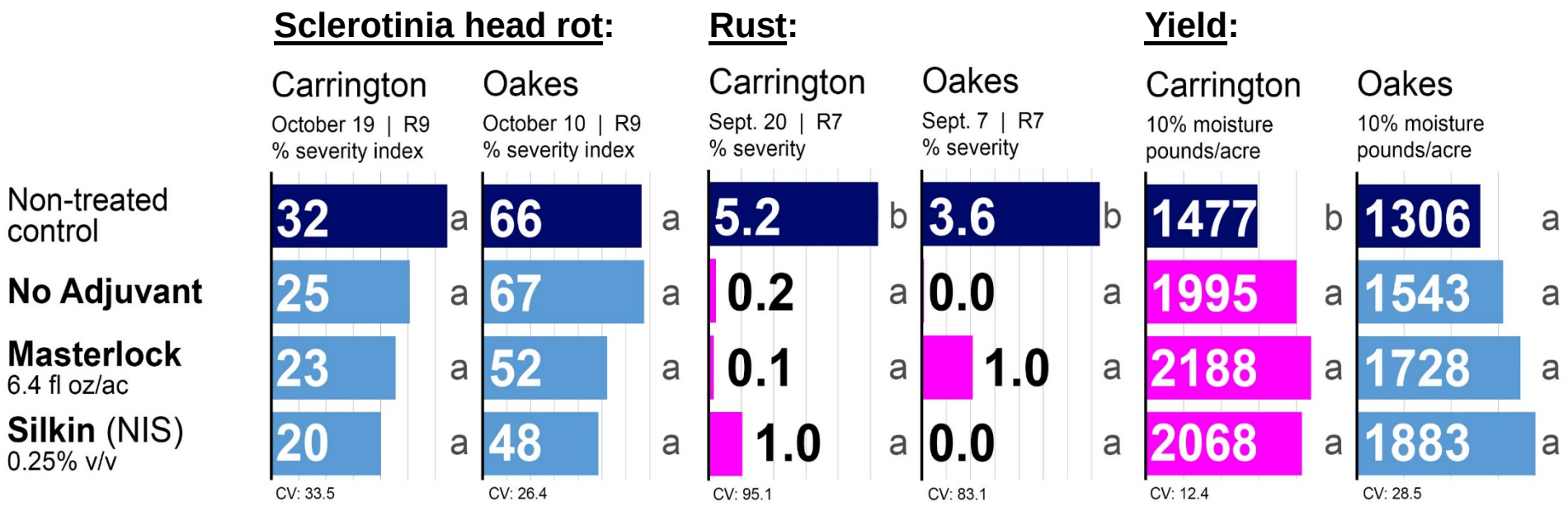
Fungicide:
Proline 480SC 5.7 fl oz/ac + Silkin (NIS) 0.25 % v/v

Spray volume: 15 gal/ac **Driving speed:** 2.6 mph
Spray nozzles, pressure: Boom-mounted: TeeJet XR11002 (flat-fan), 40 psi
Drop nozzles: 360 Undercover (360 Yield Center; Morton, IL)
Pulse-width modulation system from Capstan AG
Nozzle placement: Boom-mounted nozzles: boom set 20” above canopy

Fungicide efficacy

Carrington and Oakes, ND (2017)

Adjuvants appeared to improve fungicide performance.



Spray nozzles, application pressure:

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

Fungicide: Proline 480SC 5.7 fl oz/ac

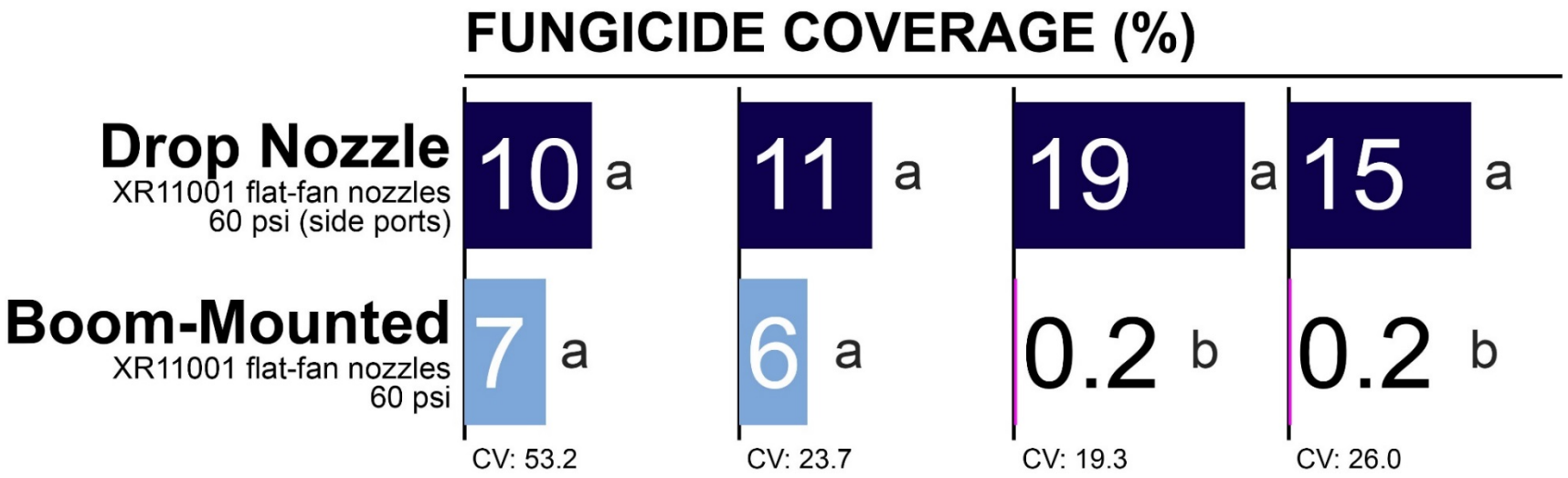
Inoculated: 3 days after fungicides applied (Carrington)
2 and 3 days after fungicides applied (Oakes)

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
Plants with open disk flowers:	**43%**	**79%**	**95%**	**100%**
Average growth stage:	**R5.0**	**R5.3**	**R5.6**	**R5.9**
Range of growth stages:	R4-R5.4	R4-R5.8	R4-R5.9	R5.1-R6.0



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

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		**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 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		**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
			percent of plants with open disk flowers:	**87%**	**95%**
			average growth stage:	**R5.4**	**R5.6**
			range of growth stages:	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 R9 growth stage % incidence	Yield 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
			percent of plants with open disk flowers:	**89%**	**95%**
			average growth stage:	**R5.5**	**R5.6**
			range of growth stages:	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 head rot
				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	10% moisture
				% incidence	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 R8 growth stage % severity	Sclerotinia head rot R9 growth stage % 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)

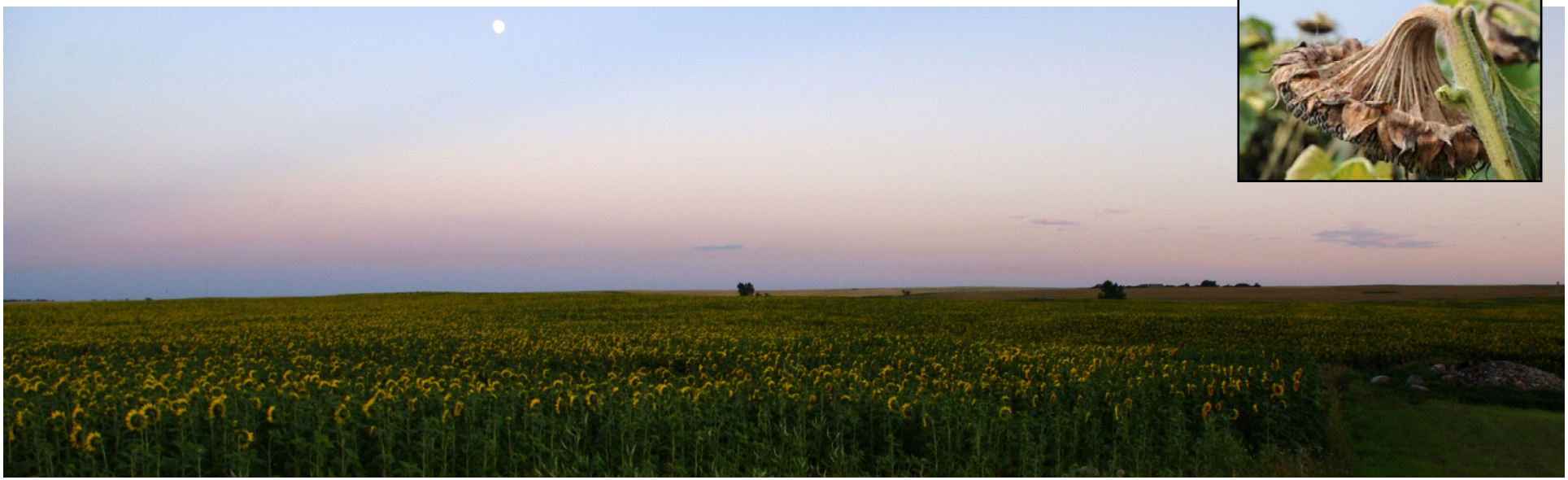
Conclusions

Multi-year, multi-location field trials

Field trials conducted from 2012-2018:

- None of the fungicides tested have provided satisfactory control of Sclerotinia head rot.
- Sclerotinia head rot control has been unsatisfactory irrespective of adjuvant use, fungicide application method, and fungicide application timing.

Thank you!



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BLOCK GRANT PROGRAM