Optimizing Fungicide Application Timing for Management of Sclerotinia in Soybeans

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Multi-location field trials conducted or coordinated by the Carrington Research Extension Center in 2014 suggest that, when environmental conditions are highly favorable for disease, Sclerotinia control may be optimized in soybeans when fungicide applications are made at the R2 growth stage (an open blossom at one of the top two nodes) irrespective of the degree of canopy closure.

In soybeans planted to intermediate and wide row spacing (21, 28, or 30 inches apart), Sclerotinia disease control and soybean yields were optimized when 8 oz/ac of Endura 70WG (boscalid, 70% by weight; BASF Corp.) was applied at the full R2 growth stage, 2 to 4 days after 80 to 90 percent of the plants had entered R2. Under conditions highly favorable for disease (cool temperatures, moist soils, and frequent rainfall and/or overhead irrigation), fungicides were slightly less effective when applied at early R2 (80-90% of the plants at R2) or when applied a week after early R2. Fungicide efficacy declined sharply when applied thereafter, even if the canopy remained open.

In soybeans planted to narrow rows (7, 7.5, 14, or 15 inches apart), 8 oz/ac of Endura applied at the early R2 growth stage (80-90% of plants at R2) consistently conferred better disease control and higher yields than 8 oz/ac of Endura applied at the R1 growth stage. Fungicide efficacy was optimized at the early R2 growth stage irrespective of the degree of canopy closure. However, fungicides were not tested at the mid- or late-R2 growth stage, and it was not clear whether disease control and yields might be further improved by delaying applications several days when 100 percent of plants had reached the R2 growth stage.

The results suggest that when conditions are highly favorable for Sclerotinia – temperatures are cool, soils are moist, and rainfall or overhead irrigation is frequent – fungicides targeting Sclerotinia in soybeans should be applied at the early- to mid-R2 growth stage, irrespective of the degree of canopy closure. Fungicide applications made at bloom initiation are less effective.

When environmental conditions favorable for Sclerotinia do not occur until later in crop development and disease onset is delayed, the optimal timing of fungicide applications may be different. A preliminary field experiment was conducted in 2014 to evaluate optimal fungicide timing when disease onset is delayed due to environmental conditions; seed yield and quality results from this trial are being processed, and results from this trial will be posted on the Carrington Research Extension Center website this winter.

These conclusions were made on the basis of trials conducted within a single field season and should be treated cautiously. To establish rigorous guidelines relative to the optimal timing of fungicide applications targeting Sclerotinia in soybeans, additional field trials are planned for 2015 and 2016.

7- or 7.5-INCH ROW SPACING

CARRINGTON, ND 7-inch row spacing

	Treatment (application timing) [z]	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
			Sept. 1	13% grain moisture	
		range (average)	*percent*	*bu/ac*	*lbs/bu*
1	**Non-treated check**		**73** b*	**25.4** c*	**59.2** a*
2	**Endura 70WG** 8 oz/ac **(R1 growth stage; A)**	**95%**	**60** b	**31.5** b	**59.3** a
3	**Endura 70WG** 8 oz/ac **(R2 growth stage; B)**	**95-100% (98%)**	**44** a	**37.3** a	**59.2** a
	F:		16.79	26.58	0.16
	P > *F*:		0.0006	< 0.0001	0.8505
	CV:		14.9	9.0	0.6

HOFFLUND, ND 7.5-inch row spacing

	Treatment (application timing) [z]	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
			Sept. 26	13% grain moisture	
		(average)	percent	bu/ac	lbs/bu
1	**Non-treated check**		**13** a*	**21.7** a*	**57.6** a*
2	**Endura 70WG** 8 oz/ac **(R1 growth stage; A)**	**100%**	**6** a	**22.3** a	**57.8** a
3	**Endura 70WG** 8 oz/ac **(R2 growth stage; B)**	**100%**	**4** a	**22.7** a	**57.8** a
	F:		3.26	0.67	0.45
	P > *F*:		0.0813	0.5316	0.6504
	CV:		76.8	6.7	0.6

[z] Fungicide application timing & methods:

CARRINGTON: (A) July 25 at 9:55-10:10 pm, 75% of plants with an open blossom (R1 growth stage); **(B)** July 31 at 12:30-12:45 pm; 90% of plants with a blossom at one of the upper two nodes (R2 growth stage), most plants with no immature pods yet at lowest nodes. *Fungicides were applied with Spraying Systems TeeJet 8001VS flat-fan nozzles in 15 gal. water/ac at 35 psi.*

HOFFLUND: (A) July 22 at 12:00 pm, 80% of plants with at least one open blossom; **(B)** July 31 at 2:00 pm, 80% of plants with an open flower at one of the two uppermost nodes. *Fungicides were applied with Spraying Systems TeeJet AI 80015 air-induction nozzles in 20 gal. water/ac at 40 psi.*

[y] Sclerotinia stem rot incidence: CARRINGTON: assessed by evaluating 90 plants in each plot (30 plants in each of three locations per plot) on Sept. 1 at the mid-R6 growth stage. HOFFLUND: assessed by evaluating a minimum of 100 plants per plot on Sept. 26 at the R8 growth stage.

14-or 15-INCH ROW SPACING

CARRINGTON, ND 14-inch row spacing

	Treatment (application timing) [z]	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
			Sept. 1	13% grain moisture	
		range (average)	percent	bu/ac	lbs/bu
1	**Non-treated check**		**85** c*	**24.9** b*	**59.2** a*
2	**Endura 70WG** 8 oz/ac **(R1 growth stage; A)**	**95%**	**68** b	**30.4** a	**59.1** a
3	**Endura 70WG** 8 oz/ac **(R2 growth stage; B)**	**96-100% (98%)**	**51** a	**31.3** a	**59.3** a
	F:		39.83	10.17	0.68
	P > *F*:		< 0.0001	0.0039	0.5261
	CV:		9.6	9.2	0.4

OAKES, ND 14-inch row spacing

Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
	Sept. 11	13% grain moisture	
(average)	percent	bu/ac	lbs/bu
	64 a*	**45.5** b*	**56.8** a*
100%	**56** a	**54.7** a	**56.7** a
100%	**54** a	**53.6** a	**56.9** a
	2.05	8.32	0.4
	0.1790	0.0075	0.6782
	16.6	8.3	0.6

LANGDON, ND 15-inch row spacing

	Treatment (application timing) [z]	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
			Sept. 7	13% grain moisture	
		range (average)	percent	bu/ac	lbs/bu
1	**Non-treated check**		**82** b*	**26.5** b*	**57.1**
2	**Endura 70WG** 8 oz/ac **(R1 growth stage; A)**	**35-60% (48%)**	**72** b	**30.0** b	**57.1**
3	**Endura 70WG** 8 oz/ac **(R2 growth stage; B)**	**70-90% (87%)**	**25** a	**39.2** a	**57.6**
	F:		89.23	26.89	2.45
	P > *F*:		< 0.0001	< 0.0001	0.1364
	CV:		13.2	9.8	0.8

[z] Fungicide application timing & methods:

CARRINGTON: (A) July 25 at 9:55-10:10 pm, 75% of plants with an open blossom; **(B)** July 31 as 12:30-12:45 pm, 90% of plants with a blossom at one of the upper two nodes. *Applied with Spraying Systems TeeJet 8001VS flat-fan nozzles in 15 gal. water/ac at 35 psi.*

OAKES: (A) July 16 at 3:37-3:45 pm, 80-90% of plants had an open blossom; **(B)** July 21 at 10:37-10:48 am, approx. 90% of plants had an open blossom at one of the top two nodes. *Applied with Spraying Systems TeeJet 8001VS flat-fan nozzles in 19 gal. water/ac at 45 psi.*

LANGDON: (A) July 16 at 12:30-1:00 pm, approx. 80% of plants had an open blossom; **(B)** July 31 at 2:10-2:40 pm, approx. 80% of plants had an open blossom at one of the top two nodes. *Applied with Spraying Systems TeeJet 8002 flat-fan nozzles in 18 gal. water/ac at 40 psi.*

[y] Sclerotinia stem rot incidence: assessed by evaluating 90 plants in each plot (30 plants in each of three locations per plot) on Sept. 1 at the mid-R6 growth stage (Carrington), Sept. 11 at the R7 growth stage (Oakes), and Sept. 7 at the R6 growth stage (Langdon).

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

14-or 15-INCH ROW SPACING

		CARRINGTON, ND 14-inch row spacing				OAKES, ND 14-inch row spacing			
	Treatment (application timing) [z]	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
		range (average	Sept. 1	13% grain moisture		(average)	Sept. 11	13% grain moisture	
			percent	bu/ac	lbs/bu		percent	bu/ac	lbs/bu
1	**Non-treated check**		**85** c*	**24.9** b*	**59.2** a*		**64** a*	**45.5** b*	**56.8** a*
2	**Endura 70WG** 8 oz/ac **(R1 growth stage; A)**	**95%**	**68** b	**30.4** a	**59.1** a	**100%**	**56** a	**54.7** a	**56.7** a
3	**Endura 70WG** 8 oz/ac **(R2 growth stage; B)**	**96-100% (98%**	**51** a	**31.3** a	**59.3** a	**100%**	**54** a	**53.6** a	**56.9** a
	F:		39.83	10.17	0.68		2.05	8.32	0.4
	P > *F*:		< 0.0001	0.0039	0.5261		0.1790	0.0075	0.6782
	CV:		9.6	9.2	0.4		16.6	8.3	0.6

[z] Fungicide application timing & methods:

CARRINGTON: (A) July 25 at 9:55-10:10 pm, 75% of plants with an open blossom; **(B)** July 31 as 12:30-12:45 pm, 90% of plants with a blossom at one of the upper two nodes. *Applied with Spraying Systems TeeJet 8001VS flat-fan nozzles in 15 gal. water/ac at 35 psi.*

OAKES: (A) July 16 at 3:37-3:45 pm, 80-90% of plants had an open blossom; **(B)** July 21 at 10:37-10:48 am, approx. 90% of plants had an open blossom at one of the top two nodes. *Applied with Spraying Systems TeeJet 8001VS flat-fan nozzles in 19 gal. water/ac at 45 psi.*

LANGDON: (A) July 16 at 12:30-1:00 pm, approx. 80% of plants had an open blossom; **(B)** July 31 at 2:10-2:40 pm, approx. 80% of plants had an open blossom at one of the top two nodes. *Applied with Spraying Systems TeeJet 8002 flat-fan nozzles in 18 gal. water/ac at 40 psi.*

[y] Sclerotinia stem rot incidence: assessed by evaluating 90 plants in each plot (30 plants in each of three locations per plot) on Sept. 1 at the mid-R6 growth stage (Carrington), Sept. 11 at the R7 growth stage (Oakes), and Sept. 7 at the R6 growth stage (Langdon).

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

28- or 30-INCH ROW SPACING

CARRINGTON, ND 28-inch row spacing

	Treatment (application timing) [z]	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
		range (average)	Sept. 1 percent	13% grain moisture bu/ac	lbs/bu
1	**Non-treated check**		**60** b*	**29.9** b*	**58.9** a*
2	**Endura 70WG** 8 oz/ac **(R1 growth stage; A)**	**50-55%**	**46** ab	**35.4** ab	**59.1** a
3	**Endura 70WG** 8 oz/ac **(R2 growth stage; B)**	**75-85% (80%)**	**34** a	**36.8** ab	**59.0** a
4	**Endura 70WG** 8 oz/ac **(1-2 days later; C)**	**80-90% (85%)**	**32** a	**40.0** a	**59.3** a
5	**Endura 70WG** 8 oz/ac **(4 days later; D)**	**85-95% (90%)**	**31** a	**38.7** a	**59.0** a
6	**Endura 70WG 8 oz/ac (7-8 days later; E)**	**96-98% (97%)**	**39** a	**36.7** ab	**59.0** a
7	**Endura 70WG 8 oz/ac (12 days later; F)**		NOT EVALUATED		
8	**Endura 70WG 8 oz/ac (22 days later; G)**		NOT EVALUATED		
9	**Endura 70WG 8 oz/ac (27 days later; H)**		NOT EVALUATED		
	F:		8.46	3.84	0.87
	P > *F*:		< 0.0001	0.0082	0.5141
	CV:		25.0	13.1	0.6

OAKES, ND 28-inch row spacing

Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
	Sept. 11	13% grain moisture	
average	percent	bu/ac	lbs/bu
	55 b*	**51.4** b*	**56.9** a*
60%	**47** ab	**56.6** ab	**56.9** a
90%	**36** a	**59.2** a	**56.7** a
95%	**34** a	**59.4** a	**56.8** a
100%	**34** a	**59.3** a	**56.9** a
	NOT EVALUATED		
	NOT EVALUATED		
	NOT EVALUATED		
	NOT EVALUATED		
	5.94	4.63	0.73
	0.0026	0.0083	0.6052
	23.5	6.8	0.6

LANGDON, ND 30-inch row spacing

	Treatment (application timing) [z]	Canopy closure when fungicides were applied	Sclerotinia incidence: [y]	Yield:	Test weight:
		range (average)	Sept. 1 percent	13% grain moisture bu/ac	lbs/bu
1	**Non-treated check**		**65** a*	**32.9** b*	**57.5** a*
2	**Endura 70WG** 8 oz/ac **(R1 growth stage; A)**	**30-45% (40%)**	**56** a	**37.1** ab	**57.5** a
3	**Endura 70WG** 8 oz/ac **(R2 growth stage; B)**	**35-65% (50%)**	**40** a	**39.8** a	**57.3** a
4	**Endura 70WG** 8 oz/ac **(1-2 days later; C)**		NOT EVALUATED		
5	**Endura 70WG** 8 oz/ac **(4 days later; D)**		NOT EVALUATED		
6	**Endura 70WG 8 oz/ac (7-8 days later; E)**		NOT EVALUATED		
7	**Endura 70WG 8 oz/ac (12 days later; F)**	**90%**	**53** a	**36.7** ab	**57.5** a
8	**Endura 70WG 8 oz/ac (22 days later; G)**	**95%**	**68** a	**33.1** ab	**57.3** a
9	**Endura 70WG 8 oz/ac (27 days later; H)**	**100%**	**72** a	**32.3** b	**57.3** a
	F:		2.54	3.70	1.15
	P > *F*:		0.0542	0.0120	0.3597
	CV:		30.4	10.8	0.5

HOFFLUND, ND 30-inch row spacing

Canopy closure when fungicides were applied	Sclerotinia incidence: [y ‡]	Yield:	Test weight:
	Sept. 1	13% grain moisture	
average	percent	bu/ac	lbs/bu
	5 b*	**30.0** a*	**57.8** a*
60%	**1** ab	**29.3** a	**57.7** a
80%	**0** a	**29.9** a	**57.8** a
	NOT EVALUATED		
90%	**2** ab	**31.0** a	**58.0** a
95%	**1** ab	**28.6** a	**57.8** a
100%	**3** ab	**29.2** a	**57.9** a
	NOT EVALUATED		
	NOT EVALUATED		
	4.67	1.90	0.37
	0.0038	0.1297	0.8623
	66.0	5.1	0.8

[z] Fungicide application timing & methods:

CARRINGTON: (A) July 25 at 9:55-10:10 pm, 75% of plants with an open blossom; **(B)** July 31 at 12:30-12:45 pm, 90% of plants with a blossom at one of the upper two nodes, fewer than 2% of plants with immature pods at lowest nodes; **(C)** August 2 at 9:45 to 9:50 pm, 100% of plants with a blossom at one of the upper two nodes, 3 to 4% of plants with immature pods up to 5 to 10 mm long at the lowest nodes; **(D)** August 4 at 9:25 to 9:35 pm, soybeans at R2 growth stage, approx. 10% of plants with immature pods approx. 10 to 15 mm long at the lowest nodes; **(E)** August 8 at 1:20 to 1:25 pm; soybeans at late R2 to early R3 growth stage, with approx. 15 to 20% of plants at R3 (pods at least 5 mm long at one of the four uppermost nodes). *Applications made with Spraying Systems TeeJet 8001VS flat-fan nozzles in 15 gal. water/ac at 35 psi.*

OAKES: (A) July 16 at 3:37-3:45 pm, 80-90% of plants had an open blossom; **(B)** July 21 at 10:37-10:48 am, approx. 90% of plants had an open blossom at one of the top two nodes; **(C)** July 22 at 1:22-1:24 pm, R2 growtth stage; **(D)** July 25 at 11:22-11:25 am, R2 growth stage. *Applied with Spraying Systems TeeJet 8001VS flat-fan nozzles in 19 gal. water/ac at 45 psi.*

LANGDON: (A) July 16 at 12:30-1:00 pm, approx. 80% of plants had an open blossom; **(B)** July 31 at 2:10-2:40 pm, approx. 80% of plants had an open blossom at one of the top two nodes; **(F)** August 12 at 10:00-10:30 am; **(G)** August 22 at 9:30-10:00 am; **(H)** August 27 at 3:30-4:00 pm. *Applied with Spraying Systems TeeJet 8002 flat-fan nozzles in 18 gal. water/ac at 40 psi.*

HOFFLUND: (A) July 22 at 12:00 pm, 80% of plants with at least one open blossom; **(B)** July 31 at 2:00 pm, 80% of plants with an open flower at one of the two uppermost nodes; **(D)** August 4 at 1:00 pm; **(E)** August 7 at 10;00 am; and **(F)** August 12 at 1:00 pm. *Fungicides were applied with Spraying Systems TeeJet AI 80015 air-induction nozzles in 20 gal. water/ac at 40 psi.*

[y] Sclerotinia stem rot incidence: CARRINGTON - assessed by evaluating 120 plants in each plot (30 plants in each of four locations per plot) on Sept. 1 at the mid-R6 growth stage; OAKES - assessed by evaluating 90 plants in each plot (30 plants in each of three locations per plot) on Sept. 11 at the R7 growth stage; LANGDON - assessed by evaluating 90 plants in each plot (30 plants in each of three locations per plot) on Sept. 6 at the R6 growth stage; HOFFLUND - assessed by evaluating a minimum of 87 plants across two locations within each plot on Sept. 26 at the R8 growth stage.

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

[‡] In order to meet model assumptions of normality and homoskedasticity, analysis of variance was conducted on the natural-log transformation of the data [LN(x + 1)]. For ease of interpretation, untransformed data are presented in the treatment means on this table.