Field evaluation of fungicides for management of Sclerotinia stem rot on soybeans

Carrington, ND (2013)

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KEY FINDINGS:

Endura (8 oz/ac) **was the only treatment to provide statistically significant improvements in disease control and soybean yield in this trial.** The performance of Endura (5.5 oz/ac) and of Proline (3 fl oz/ac) + Topsin (20 fl oz/ac) was intermediate. Aproach (9 fl oz/ac) did not show efficacy against Sclerotinia in this trial.

Excellent Sclerotinia control was achieved in this trial when fungicides were applied after bloom and approx. 2 to 4 days prior to canopy closure. Additional research is needed to confirm that this application timing is optimal.

Active ingredients of fungicides tested in this trial:

Endura contains 700 grams boscalid per kilogram

Proline contains 480 grams prothioconazole per liter

Aproach contains 250 grams picoxystrobin per liter

Topsin contains 540 grams thiophanate-methyl per liter.

FULL RESULTS, COMBINED ANALYSIS OF ALL ROW SPACINGS

Description (application timing)[z]	Plant population:[y] June 20[s] plants/ac	Sclerot. wilt symptoms:[w] Aug. 25[s] % of canopy	Sclerotinia incidence:[v] Sept. 13, 15[s] percent	Sclerotinia severity:[u] Sept. 13, 15[s] 1 to 3	Sclerotinia sev. index:[t] Sept. 13, 15[s] 0 to 3	Yield 13% moisture bu/ac	Test weight 13% moisture lbs/bu	Seeds per pound 13% moisture seeds/lb	Protein 13% moisture percent	Oil 13% moisture percent
1 **Non-treated check**	**170701**	**37** b*	**62** b*	**2.80** a*	**1.74** b*	**37.2** b*	**58.8** a*	**2799** a *	**37.3** a *	**14.3** a *
2 **Proline 480SC** 3 fl oz/ac + **Topsin 4.5FL** 20 fl oz/ac **(A)**	**180573**	**25** ab	**53** ab	**2.78** a	**1.48** ab	**41.6** ab	**59.0** a	**2818** a	**37.1** a	**14.5** a
3 **Aproach 250SC** 9 fl oz/ac + **NIS** 0.25% v/v **(A)**	**177155**	**32** b	**62** b	**2.85** a	**1.76** b	**37.5** b	**58.8** a	**2817** a	**37.1** a	**14.5** a
4 **Endura 70WG** 5.5 oz/ac **(A)**	**172815**	**16** a	**54** ab	**2.80** a	**1.53** ab	**42.7** a	**59.0** a	**2744** a	**37.2** a	**14.2** a
5 **Endura 70WG** 8 oz/ac **(A)**	**170905**	**13** a	**44** a	**2.75** a	**1.20** a	**45.4** a	**59.1** a	**2813** a	**36.9** a	**14.3** a
F:		7.41	6.31	2.33	6.90	7.60	0.84	0.94	1.13	1.81
P > *F*:		< 0.0001	0.0001	0.0602	< 0.0001	< 0.0001	0.5055	0.4461	0.3478	0.1327
CV:		74.7	27.1	4.1	25.6	15.3	0.9	5.7	1.7	2.9

[z] **Fungicide application timing:**

Application A: July 19 at 7:30 to 8:15 am; just prior to canopy closure in the soybeans seeded to 7-inch and 14-inch rows; R2 growth stage; no Sclerotinia present; wind = 7 to 8 mph, air temperature = 65 to 72°F, relative humidity = 70 to 83%.

Application B: July 25 at 8:30 to 9:00 am; just prior to canopy closure in the soybeans seeded to 21-inch rows; late R2 to early R3 growth stage; no Sclerotinia present; wind = 6.0 to 6.4 mph out of the northwest, air temperature = 65.6 to 66.1°F, relative humidity = 79.9 to 80.1%

Application C: August 7 at 12:10 to 12:40 pm; canopy closure in the soybeans seeded to 28-inch rows; R4 growth stage; no Sclerotinia present; wind = 3.2 to 4.5 mph out of the eas to southeast; air temperature = 73 to 83°F, relative humidity = 35.5 to 52%

[y] **Plant population:** Assessed on June 20 at the VC to V1 growth stage (unifoliate to first trifoliate leaves unfolded) by counting all plants along a 9-meter length of row in each plot (in plots with a 7-inch row spacing, a 2.25-meter length was counted in rows 2, 3, 5, and 6 of the seven rows of each plot; in plots with a 14-inch row spacing, a 2.25-meter length was counted on all four rows of each plot; in plots with a 21-inch row spacing, a 3-meter length was counted on all three rows of each plot; in plots with a 28-inch row spacing, a 4.5-meter length was counted in both rows of each plot).

[x] **Phytotoxicity:** Percent crop injury compared to the non-treated check. A rating of zero indicates no crop injury. This assessment was taken 7 days after a fungicide application was made.

[w] **Sclerotinia wilt symptoms:** Percent of the canopy exhibiting wilt symptoms caused by Sclerotinia stem rot.

[v] **Sclerotinia stem rot incidence** was assessed by evaluating 75 plants in each plot (25 plants in each of three locations per plot).

[u] **Sclerotinia severity:** Average disease severity among plants expressing Sclerotinia stem rot. A 1 to 3 scale was employed: 1 = lesions on lateral branches only, 2 = lesions on main stem, no wilt, and normal pod development, 3 = lesions on main stem resulting in wilting, poor pod fill, and plant death. In each plot, 75 plants were evaluated (25 plants in each of three locations per plot).

[t] **Sclerotinia disease severity index:** Average disease severity across all plants, including those without any disease. A 0 to 3 scale was employed: 0 = no symptoms, 1 = lesions on lateral branches only, 2 = lesions on main stem, no wilt, and normal pod development, 3 = lesions on main stem resulting in wilting, poor pod fill, and plant death. In each plot, 75 plants were evaluated (25 plants in each of three locations per plot).

[s] **On July 25, the soybeans were at R6 growth stage (one or more pods containing a green seed that fills pod capacity at one of the four uppermost nodes on the main stem)**

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

‡ In order to meet meet model assumptions of normality and homoskedasticity, analysis of variance was conducted on the natural-log transformation of disease severity [LN(x + 1)]. For ease of interpretation, treatment means are reported as disease severity.

7-INCH ROW SPACING:	Plant population: [y]	Sclerot. wilt symptoms: [w]	Sclerotinia incidence: [v]	Sclerotinia severity: [u]	Sclerotinia sev. index: [t]	Yield	Test weight	Seeds per pound	Protein	Oil
	June 20 [s]	Aug. 25 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	13% moisture	13% moisture	13% moisture	13% moisture	13% moisture
Description (application timing) [z]	plants/ac	% of canopy	percent	1 to 3	0 to 3	bu/ac	lbs/bu	seeds/lb	percent	percent
1 **Non-treated check**	**169469**	**50** b*	**65** a*	**2.82** a*	**1.84** a*	**36.1** a*	**59.0** a*	**2751** a *	**37.6** a *	**14.3** a *
2 **Proline 480SC** 3 fl oz/ac + **Topsin 4.5FL** 20 fl oz/ac **(A)**	**176292**	**37** ab	**60** a	**2.79** a	**1.69** a	**37.4** a	**59.2** a	**2907** a	**36.7** ab	**14.7** a
3 **Aproach 250SC** 9 fl oz/ac + **NIS** 0.25% v/v **(A)**	**179058**	**30** ab	**65** a	**2.87** a	**1.87** a	**38.3** a	**59.0** a	**2760** a	**37.2** ab	**14.3** a
4 **Endura 70WG** 5.5 oz/ac **(A)**	**175924**	**19** a	**60** a	**2.84** a	**1.69** a	**41.2** a	**58.9** a	**2777** a	**37.3** ab	**14.2** a
5 **Endura 70WG** 8 oz/ac **(A)**	**159696**	**18** a	**52** a	**2.76** a	**1.44** a	**42.8** a	**59.4** a	**2878** a	**36.5** b	**14.5** a
F:		3.93	1.45	1.55	1.84	1.77	1.03	2.07	3.44	1.62
P > *F*:		0.0163	0.2534	0.2275	0.1607	0.1738	0.4168	0.1232	0.0271	0.2093
CV:		53.8	18.0	3.0	18.0	13.0	0.8	4.4	1.6	2.9

14-INCH ROW SPACING:	Plant population: [y]	Sclerot. wilt symptoms: [w]	Sclerotinia incidence: [v]	Sclerotinia severity: [u]	Sclerotinia sev. index: [t]	Yield	Test weight	Seeds per pound	Protein	Oil
	June 20 [s]	Aug. 25 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	13% moisture	13% moisture	13% moisture	13% moisture	13% moisture
Description (application timing) [z]	plants/ac	% of canopy	percent	1 to 3	0 to 3	bu/ac	lbs/bu	seeds/lb	percent	percent
1 **Non-treated check**	**167968**	**33** bc*	**64** a*	**2.78** a*	**1.78** a*	**36.7** a*	**58.8** a*	**2828** a *	**37.1** a *	**14.2** a *
2 **Proline 480SC** 3 fl oz/ac + **Topsin 4.5FL** 20 fl oz/ac **(A)**	**183774**	**31** bc	**64** a	**2.77** a	**1.78** a	**40.9** a	**58.7** a	**2797** a	**37.5** a	**14.2** a
3 **Aproach 250SC** 9 fl oz/ac + **NIS** 0.25% v/v **(A)**	**180191**	**47** c	**68** a	**2.83** a	**1.94** a	**33.5** a	**58.6** a	**2853** a	**37.2** a	**14.6** a
4 **Endura 70WG** 5.5 oz/ac **(A)**	**186303**	**13** a	**54** a	**2.80** a	**1.52** a	**42.2** a	**59.0** a	**2818** a	**37.1** a	**14.1** a
5 **Endura 70WG** 8 oz/ac **(A)**	**171129**	**18** ab	**55** a	**2.77** a	**1.54** a	**41.1** a	**58.8** a	**2818** a	**37.2** a	**14.2** a
F:		3.33	0.72	0.40	0.75	1.72	0.25	0.10	0.49	1.2
P > *F*:		0.0302	0.5683	0.8063	0.5719	0.1844	0.9078	0.9828	0.7465	0.3407
CV:		63.5	28.8	3.4	29.5	17.6	1.0	5.8	1.5	2.7

21-INCH ROW SPACING:	Plant population: [y]	Sclerot. wilt symptoms: [w]	Sclerotinia incidence: [v]	Sclerotinia severity: [u]	Sclerotinia sev. index: [t]	Yield	Test weight	Seeds per pound	Protein	Oil
	June 20 [s]	Aug. 25 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	13% moisture	13% moisture	13% moisture	13% moisture	13% moisture
Description (application timing) [z]	plants/ac	% of canopy	percent	1 to 3	0 to 3	bu/ac	lbs/bu	seeds/lb	percent	percent
1 **Non-treated check**	**179085**	**40** c*	**64** b*	**2.81** a*	**1.81** b*	**38.0** b*	**58.7** a*	**2860** a *	**37.2** a *	**14.5** a *
2 **Proline 480SC** 3 fl oz/ac + **Topsin 4.5FL** 20 fl oz/ac **(B)**	**200265**	**4** a	**39** a	**2.75** a	**1.07** a	**47.7** ab	**59.2** a	**2807** a	**36.9** a	**14.3** a
3 **Aproach 250SC** 9 fl oz/ac + **NIS** 0.25% v/v **(B)**	**171182**	**26** bc	**66** b	**2.78** a	**1.83** b	**39.1** b	**58.6** a	**2822** a	**37.0** a	**14.3** a
4 **Endura 70WG** 5.5 oz/ac **(B)**	**170233**	**11** ab	**52** ab	**2.76** a	**1.44** ab	**47.0** ab	**59.0** a	**2751** a	**37.1** a	**14.4** a
5 **Endura 70WG** 8 oz/ac **(B)**	**181139**	**5** a	**37** a	**2.68** a	**1.00** a	**52.7** a	**59.1** a	**2756** a	**36.8** a	**14.3** a
F:		9.06	8.73	0.57	8.18	5.12	2.64	0.54	0.54	0.56
P > *F*:		0.0002	0.0003	0.6852	0.0004	0.0052	0.0641	0.7094	0.7065	0.6918
CV:		32.6	22.1	5.6	23.7	15.0	0.6	5.5	1.4	2.0

28-INCH ROW SPACING:	Plant population: [y]	Sclerot. wilt symptoms: [w]	Sclerotinia incidence: [v]	Sclerotinia severity: [u]	Sclerotinia sev. index: [t]	Yield	Test weight	Seeds per pound	Protein	Oil
	June 20 [s]	Aug. 25 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	Sept. 13, 15 [s]	13% moisture	13% moisture	13% moisture	13% moisture	13% moisture
Description (application timing) [z]	plants/ac	% of canopy	percent	1 to 3	0 to 3	bu/ac	lbs/bu	seeds/lb	percent	percent
1 **Non-treated check**	**166282**	**25** a*	**55** b*	**2.82** a*	**1.55** b*	**38.3** a*	**58.9** a*	**2758** a *	**37.2** a *	**14.3** a *
2 **Proline 480SC** 3 fl oz/ac + **Topsin 4.5FL** 20 fl oz/ac **(C)**	**161961**	**27** a	**49** ab	**2.80** a	**1.37** ab	**40.4** a	**58.8** a	**2764** a	**37.2** a	**14.6** a
3 **Aproach 250SC** 9 fl oz/ac + **NIS** 0.25% v/v **(C)**	**178189**	**26** a	**48** ab	**2.91** a	**1.38** ab	**38.9** a	**59.2** a	**2833** a	**36.9** a	**14.6** a
4 **Endura 70WG** 5.5 oz/ac **(C)**	**158800**	**21** a	**51** ab	**2.82** a	**1.46** ab	**40.6** a	**59.1** a	**2629** a	**37.2** a	**14.0** a
5 **Endura 70WG** 8 oz/ac **(C)**	**171656**	**11** a	**30** a	**2.78** a	**0.82** a	**45.1** a	**59.0** a	**2798** a	**37.1** a	**14.3** a
F:		0.61	2.96	1.04	2.99	1.57	0.50	1.52	0.34	1.64
P > *F*:		0.6583	0.0453	0.4120	0.0435	0.2214	0.7331	0.2342	0.8455	0.2028
CV:		89.5	30.2	4.2	30.6	12.9	0.9	5.6	1.8	3.2

[z] **Fungicide application timing:**

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Application B: July 25 at 8:30 to 9:00 am; just prior to canopy closure in the soybeans seeded to 21-inch rows; late R2 to early R3 growth stage; no Sclerotinia present; wind = 6.0 to 6.4 mph out of the northwest, air temperature = 65.6 to 66.1˚F, relative humidity = 79.9 to 80.1%

Application C: August 7 at 12:10 to 12:40 pm; canopy closure in the soybeans seeded to 28-inch rows; R4 growth stage; no Sclerotinia present; wind = 3.2 to 4.5 mph out of the eas to southeast; air temperature = 73 to 83˚F, relative humidity = 35.5 to 52%

[y] **Plant population:** Assessed on June 20 at the VC to V1 growth stage (unifoliate to first trifoliate leaves unfolded) by counting all plants along a 9-meter length of row in each plot (in plots with a 7-inch row spacing, a 2.25-meter length was counted in rows 2, 3, 5, and 6 of the seven rows of each plot; in plots with a 14-inch row spacing, a 2.25-meter length was counted on all four rows of each plot; in plots with a 21-inch row spacing, a 3-meter length was counted on all three rows of each plot; in plots with a 28-inch row spacing, a 4.5-meter length was counted in both rows of each plot).

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METHODS:

- **Location of trial:** NDSU Carrington Research Extension Center, Carrington, ND.
- **GPS coordinates of research trial location:** 47.508, -99.131
- **Soil type:** Heimdal-Emrick loam
- **Tillage:** Disked in October 2012. Deep cultivation conducted May 24, 2013; shallow cultivation conductd May 25, 2013.
- **Rhizobium inoculant:** Cell-Tech granular nitrogen fixing inoculant for soybean (Bradyrhizobium japonicum, 100 million viable cells per gram; Novozymes BioAg, Saskatoon, SK Canada) was mixed with the seed and applied at a rate of 2 dry ounces per 1000 feet of row.
- **Maintenance herbicide applications:** Touchdown Total (24 fl oz/ac; 5.1 lbs ai per gallon of glyphosate in the form of its isopropylamine salt = 4.17 lbs per gallon of the acid glyphosate), Warrant (1.25 qt/ac; acetochlor, 33% and 3 lbs ai/gallon), and Blue Diamond Activator (2 qt per 100 gallons; 100% ammonium sulfate; NWC N.D., Inc., Emerado, ND) were applied at the VC to V1 growth stage (unifoliate to first trifoliate leaves unfolded) on June 22.
- **Variety:** Dairyland 'DSR0404/R2Y'. Untreated seed was used.
- **Experimental design:** randomized complete block with a split-plot arrangement **Replicates:** 6
  Main factor: row spacing (7, 14, 21, or 28 inches between rows) **Sub factor:** fungicide treatment
- **Seeded plot size:** 5 ft (center-to-center) x 25 ft long **Harvested plot size:** 5 ft (center-to-center) x approx. 19 ft long
- **Untreated buffer plots were established between treatment plots.**
- **Row spacing and rows per plot:** Treatment plots consisted of 7 rows, each 7 inches apart; 4 rows, each 14 inches apart; 3 rows, each 21 inches apart; or 2 rows, each 28 inches apart. Buffer and guard plots consisted of 4 rows, each 14 inches apart.
- **Planting date:** May 26, 2013 **Seeding rate:** 165,000 pure live seeds/ac **Previous crop:** dry edible (pinto) beans
- **Fungicide application A:** July 19 at 7:30 to 8:15 am; just prior to canopy closure in the soybeans seeded to 7-inch and 14-inch rows; R2 growth stage; no Sclerotinia present; wind = 7 to 8 mph, air temperature = 65 to 72˚F, relative humidity = 70 to 83%.
- **Fungicide application B:** July 25 at 8:30 to 9:00 am; just prior to canopy closure in the soybeans seeded to 21-inch rows; late R2 to early R3 growth stage; no Sclerotinia present; wind = 6.0 to 6.4 mph out of the northwest, air temperature = 65.6 to 66.1˚F, relative humidity = 79.9 to 80.1%
- **Fungicide application C:** August 7 at 12:10 to 12:40 pm; canopy closure in the soybeans seeded to 28-inch rows; R4 growth stage; no Sclerotinia present; wind = 3.2 to 4.5 mph out of the eas to southeastt; air temperature = 73 to 83˚F, relative humidity = 35.5 to 52%
- **Fungicide application details:** Fungicides were applied with a 57-inch hand boom equipped with four equally spaced Spraying Systems TeeJet XR 8001VS flat-fan nozzles at a spray volume of 15 gal water/A operated at 35 psi.
- **Plant population:** Assessed on June 20 at the VC to V1 growth stage (unifoliate to first trifoliate leaves unfolded) by counting all plants along a 9-meter length of row in each plot (in plots with a 7-inch row spacing, a 2.25-meter length was counted in rows 2, 3, 5, and 6 of the seven rows of each plot; in plots with a 14-inch row spacing, a 2.25-meter length was counted on all four rows of each plot; in plots with a 21-inch row spacing, a 3-meter length was counted on all three rows of each plot; in plots with a 28-inch row spacing, a 4.5-meter length was counted in both rows of each plot).
- **Disease establishment:** The trial was established on a site with a previous history of Sclerotinia epidemics. In addition, sclerotia of Sclerotinia sclerotiorum obtained from a sunflower processing plant were applied to plots on June 14. Three to five sclerotia were placed approx. 0.5 inches deep in each of six locations per plot. Half of the sclerotia placed in the plots had overwintered outside and were naturally vernalized; the other half were artificially vernalized by alternating them between a freezer (-20C for at least 12 hours) and room temperature (20 to 25C for at least 8 hours) a minimum of eight times.
- **Sclerotinia disease assessment:** Sclerotinia incidence and severity were assessed on September 13 and 15 at the late R6 growth stage (pod containing a green seed that fills the pod capacity at one of the four uppermost nodes on the main stem) to early R7 growth stage (one normal pod on the main stem has reached its mature pod color) using the 0 to 3 scale developed by Craig Grau (Grau and Radke 1984; Plant Disease 68: 56-58): 0 = no symptoms, 1 = lesions on lateral branches only, 2 = lesions on main stem, no wilt, and normal pod development, 3 = lesions on main stem resulting in wilting, poor pod fill, and plant death. In each plot, 75 plants were evaluated (25 plants in each of three locations per plot).
- **Harvest date:** October 13
- **Seed yield and quality:** Plot-level grain moisture levels were assessed at the time of seed yield and quality assessment, and all seed yield, test weight, and kernel weight data were adjusted to 13% grain moisture.
- **Statistical analysis:** Data were evaluated with analysis of variance . The assumption of constant variance was assessed by plotting residuals against predicted values, and the assumption of normality was assessed with a normal probability plot. All data met model assumptions. Single-degree-of-freedom contrasts were performed for all pairwise comparisons of isolates; to control the Type I error rate at the level of the experiment, the Tukey multiple comparison procedure was employed. Analyses were conducted with replicate and treatment as main factor effects, and they were implemented in PROC GLM of SAS (version 9.2; SAS Institute, Cary, NC).

FUNDING:

This project was funded by the **North Dakota Soybean Council.**

IMPORTANT NOTICE:

Fungicide performance can differ in response to which diseases are present, levels of disease when products are applied, environmental conditions, plant architecture and the susceptibility to disease of the variety planted, crop growth stage at the time of fungicide application, and other factors.

This report summarizes fungicide performance as tested at the NDSU Carrington Research Extension Center under the conditions partially summarized in this report. Fungicide efficacy may differ under other conditions; when choosing fungicides, always evaluate results from multiple trials.

This report is shared for educational purposes and is not an endorsement of any specific products.