

Field evaluation Contans for management of Sclerotinia stem rot on soybeans: Optimizing the application rate (1 vs. 2 lbs/ac) and application timing (fall vs. spring)

Carrington, ND (2012)

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KEY FINDINGS:

In this trial, sclerotia of *Sclerotinia sclerotiorum* were primarily on the soil surface at the time of Contans applications. Under these conditions:

- Contans reduced both the viability and the vigor of sclerotia: Fewer sclerotia germinated to form apothecia, and the sclerotia that germinated produced fewer apothecia.
- Fall applications of Contans were more effective than spring applications.
- Contans performed equivalently when applied at 1 lb/ac and 2 lbs/ac. There was no benefit to using the higher application rate.

The effect of Contans applications on Sclerotinia disease control and soybean yield could not be rigorously assessed in this trial. Plot sizes were small, and the effect of Contans applications on disease control and soybean yield were diluted by the movement of Sclerotinia spores into plots from non-treated areas adjacent to the plots.

The results suggest that Contans may be a useful tool for degrading sclerotia of *S. sclerotiorum* and reducing Sclerotinia disease pressure. Sclerotia were primarily on the soil surface when Contans was applied, and similar results would be expected when Contans is applied directly to crop residues and sclerotia after the a white-mold-infested crop is harvested (and before tillage operations bury the sclerotia).

IMPORTANT BACKGROUND INFORMATION:

Photos of diseased sunflowers courtesy of Sam Markell

In North Dakota, Sclerotinia diseases are caused by the fungus *Sclerotinia sclerotiorum*.

- S. sclerotiorum* produces black fungal resting structures known as sclerotia.
- The sclerotia are produced in and on diseased plant tissues.
- Sclerotia can persist in the soil for many years.
- Sclerotia sometimes produce fungal growth that directly invades susceptible crops. Direct germination generally causes basal stalk rot.
- Sclerotia in the top 1.5 inches of the soil often germinate to produce apothecia, tiny mushroom-like structures that are often 0.1 to 0.4 inches in diameter.
- Apothecia release spores into the crop canopy. When spores successfully colonize host plant tissues, disease develops.
- Reducing the number of viable sclerotia and the number of apothecia reduces Sclerotinia disease pressure.

SCLEROTIA PRODUCED IN/ON DISEASED CROPS:



APOTHECIA:



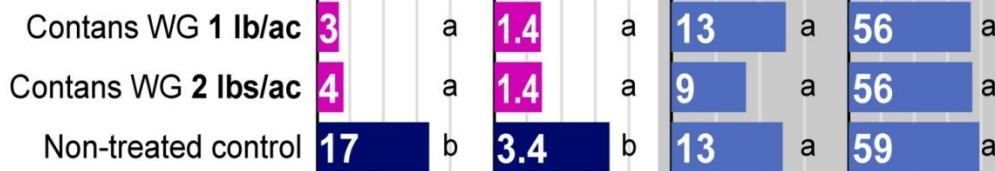
SUMMARY OF KEY RESULTS:

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

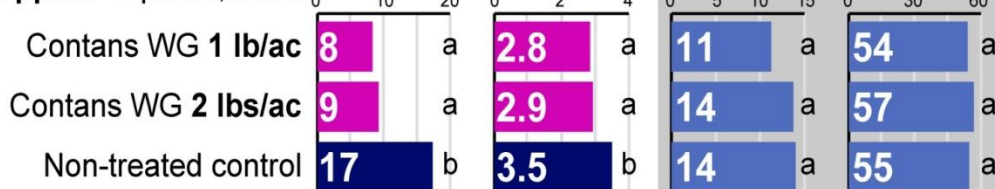
Disease control and soybean yield data from this study should be treated cautiously.

The effect of Contans applications on Sclerotinia disease control and soybean yield could not be rigorously assessed in this trial. Plot sizes were small, and the effect of Contans applications on disease control and soybean yield were diluted by the movement of Sclerotinia spores into plots from non-treated areas adjacent to the plots.

Fall application - Oct. 11, 2011



Spring applic. - Apr. 24, 2012



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DETAILED RESULTS:

TREATMENT & APPLICATION RATE	DATE OF TREATMENT IMPOSITION	INCORPORATION METHOD ^{x,y}	APOTHECIA [†]	CARPOGENICALLY GERMINATED SCLEROTIA ^z	SCLEROTINIA INCIDENCE [‡]	YIELD	TEST WEIGHT	SEEDS PER POUND
			number per square meter	number per square meter	percent	bu/ac	lbs/bu	seeds
			Aug. 27-29, 31 ^w	Aug. 27-29, 31 ^w	Aug. 27-29, 31 ^w	13% moisture	13% moisture	13% moisture
1 Contans 1 lb/ac	Oct. 11, 2011	manual ^y + water incorporation ^x	2.5 a *	1.4 a *	16 a *	54.4 a *	57.7 a *	2870 a *
2 Contans 1 lb/ac	Oct. 11, 2011	manual + water incorporation	3.8 a	1.5 a	14 a	52.9 a	57.9 a	2886 a
3 Contans 1 lb/ac	Oct. 11, 2011	manual + water incorporation	3.2 a	1.4 a	8 a	59.2 a	58.0 a	2864 a
4 Contans 2 lb/ac	Oct. 11, 2011	manual + water incorporation	2.9 a	1.6 a	6 a	58.0 a	58.0 a	2858 a
5 Contans 2 lb/ac	Oct. 11, 2011	manual + water incorporation	5.6 a	1.4 a	9 a	55.3 a	57.5 a	2880 a
6 Contans 2 lb/ac	Oct. 11, 2011	manual + water incorporation	3.1 a	1.3 a	10 a	55.2 a	57.7 a	2874 a
7 Control (no Contans)	Oct. 11, 2011	manual + water incorporation	16.8 b	3.4 b	13 a	59.0 a	57.7 a	2827 a
F:			4.03	4.78	0.84	0.88	0.43	0.23
P>F:			0.0050	0.0018	0.5467	0.5196	0.8518	0.9649
CV:			45.2	50.6	31.8	11.4	1.0	3.5
1 Contans 1 lb/ac	April 24, 2012	manual ^y + water incorporation ^x	10.1 a *	3.4 a *	14 a *	50.0 a *	57.9 a *	2958 a *
2 Contans 1 lb/ac	April 24, 2012	manual + water incorporation	9.0 a	2.7 a	11 a	54.9 a	58.0 a	2877 a
3 Contans 1 lb/ac	April 24, 2012	manual + water incorporation	5.9 a	2.4 a	9 a	58.5 a	57.7 a	2932 a
4 Contans 2 lb/ac	April 24, 2012	manual + water incorporation	7.1 a	2.6 a	13 a	57.0 a	57.9 a	2901 a
5 Contans 2 lb/ac	April 24, 2012	manual + water incorporation	10.0 a	3.2 a	10 a	59.4 a	57.8 a	2854 a
6 Contans 2 lb/ac	April 24, 2012	manual + water incorporation	9.5 a	3.0 a	19 a	54.3 a	57.6 a	2924 a
7 Control (no Contans)	April 24, 2012	manual + water incorporation	17.3 a	3.5 a	14 a	54.8 a	57.8 a	2878 a
F:			1.89	0.51	1.21	1.77	0.68	0.45
P>F:			0.1187	0.7967	0.3318	0.1419	0.6633	0.8355
CV:			25.4	47.2	27.3	10.4	0.7	4.6

^z Carpogenically germinated sclerotia: Sclerotia that germinated to produce apothecia.

^y Manual incorporation: Contans was incorporated within 4 hrs of application to approx. 1.5 inches deep by harrowing.

^x Water incorporation: The trial was conducted under a center pivot, and 1 inch of water was applied to the plots within 24 hrs of Contans applications.

^w Growth stage on Aug. 27-29 and Aug. 31 was R6 (full seed; at least one pod at the four uppermost nodes contain green seeds that fill the pod capacity).

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

[‡] To meet model assumptions of normality and homoskedasticity, analysis of variance was conducted on the natural-log transformation of apothecia number disease incidence [$\ln(x + 1)$]. For ease of interpretation, treatment means are reported as the (untransformed) apothecia number and percent disease.

ANOVA TABLE: Sclerotinia incidence [†]					
	df	SS	MS	F	P > F
Total (subplots)	83	40.8			
Replicate	5	3.2	0.7	0.52	0.7571
Timing (A)	1	0.4	0.4	0.30	0.6085
Error A (Rep * A)	5	6.3	1.3		
Treatment (B)	6	4.1	0.7	1.64	0.1515
Interaction (A*B)	6	1.6	0.3	0.64	0.6988
Error B	60	25.2	0.4		

[†] To meet model assumptions of normality and homoskedasticity, analysis of variance was conducted on the natural-log transformation of disease incidence [$\ln(x + 1)$].

ANOVA TABLE: Apothecia [†]					
	df	SS	MS	F	P > F
Total (subplots)	83	52.8			
Replicate	5	1.1	0.2	0.37	0.8529
Timing (A)	1	10.0	10.0	17.32	0.0088
Error A (Rep * A)	5	2.9	0.6		
Treatment (B)	6	12.3	2.0	5.09	0.0003
Interaction (A*B)	6	2.6	0.4	1.07	0.3926
Error B	60	28.7	1.3		

[†] To meet model assumptions of normality and homoskedasticity, analysis of variance was conducted on the natural-log transformation of apothecia number [$\ln(x + 1)$].

ANOVA TABLE: Carpogenically germinated sclerotia					
	df	SS	MS	F	P > F
Total (subplots)	83	172.5			
Replicate	5	10.9	2.2	1.46	0.2173
Timing (A)	1	34.8	34.8	16.81	0.0094
Error A (Rep * A)	5	10.4	2.1		
Treatment (B)	6	19.3	3.2	2.16	0.0600
Interaction (A*B)	6	7.8	1.3	0.87	0.5189
Error B	60	89.4	1.5		

ANOVA TABLE: Yield					
	df	SS	MS	F	P > F
Total (subplots)	83	3152			
Replicate	5	964	193	11.26	0.0094
Timing (A)	1	12	12	0.69	0.4442
Error A (Rep * A)	5	86	17		
Treatment (B)	6	404	67	2.66	0.0233
Interaction (A*B)	6	169	28	1.11	0.3652
Error B	60	1517	25		

ANOVA TABLE: Test Weight					
	df	SS	MS	F	P > F
Total (subplots)	83	20.7			
Replicate	5	7.5	1.5	4.02	0.0766
Timing (A)	1	0.0	0.0	0.05	0.8245
Error A (Rep * A)	5	1.9	0.4		
Treatment (B)	6	0.9	0.2	0.94	0.4764
Interaction (A*B)	6	0.6	0.1	0.66	0.6851
Error B	60	9.8	0.2		

ANOVA TABLE: Seeds per pound					
	df	SS	MS	F	P > F
Total (subplots)	83	997149			
Replicate	5	171930	34386	4.75	0.0563
Timing (A)	1	30222	30222	4.17	0.0966
Error A (Rep * A)	5	36226	7245		
Treatment (B)	6	31549	5258	0.45	0.8404
Interaction (A*B)	6	30037	5006	0.43	0.8555
Error B	60	697184	11620		

Interpretation of ANOVA tables:

- Application timing of Contans (spring vs. fall) had a significant effect on the number of apothecia and the number of viable (carpogenically germinated) sclerotia produced below the soybean canopy. It did not have a significant effect on Sclerotinia incidence, soybean yield, test weight, or kernel weight.
- Application rate of Contans (0, 1, or 2 lbs/ac) had a significant effect on the number of apothecia and the number of carpogenically germinated sclerotia produced below the soybean canopy. It did not have a significant effect on Sclerotinia incidence, soybean yield, test weight, or kernel weight.
- The relative performance of Contans applied at 0, 1, or 2 lbs/ac was similar irrespective of application timing (spring vs. fall); there were no significant interaction effects between application timing and application rate of Contans.

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METHODS:

- **Location of trial:** North Dakota State University Carrington Research Extension Center (47.514, -99.134). The trial was established on the irrigated footprint of a 44-acre field with center pivot irrigation; the soil type was a Heimdal-Emrick loam.
- **Tillage:** The field used for this study was under long-term conventional tillage. It was disked once and cultivated once in September 2011 prior to the first application of Contans. To ensure that the Contans-treated soil remained on the surface of the field, no further tillage operations beyond a light harrowing were conducted after applying Contans. Soybeans were direct-seeded in the spring.
- **Previous crop:** spring wheat
- **Variety:** 'Ashtabula', a conventional variety (not resistant to glyphosate)
- **Planting date:** May 11, 2012.
- **Seeding rate:** 175,000 pure live seeds per acre.
- **Row spacing:** 15 inches
- **Experimental design:** The spring vs. fall application timing experiment was arranged as a completely randomized split-plot design. Application timing (fall vs. spring) was the main factor, and application rate (0, 1, or 2 lbs/ac) was the sub-factor. The 1 lb/ac and 2 lb/ac application rates were tested three times in order to permit the subsequent evaluation of the application timing and frequency of Contans over a three-year soybean-spring wheat-soybean rotation.
- **Replicates:** 6
- **Plot size and layout:** Plots were 15 ft x 15 ft and separated from each other by 60 ft. Plots were separated by 60 feet in order to minimize the effects of neighboring plots on disease levels; within a soybean canopy, spores of *S. sclerotiorum* have been documented to be distributed 60 feet from their point of origin. Because native Sclerotinia levels were assumed to be fairly low, Contans was not applied between the plots. In retrospect, Contans should have been applied between plots, as Sclerotinia pressure was very high in this field. Beginning in October 2012 and continuing in every subsequent year of the experiment, fall applications of Contans will be made between plots. Contans applications were made to a 20 ft x 20 ft block centered on the 15 ft x 15 ft treatment plot.
- **Inoculation:** 50 grams of sclerotia of *Sclerotinia sclerotiorum* were applied to the surface of each plot on October 6 to 7, 2011. All sclerotia used in this experiment were obtained from diseased sunflowers.
- **Contans application method:** Contans was applied with a 100-inch hand-held spray boom with six equally spaced Spraying Systems TeeJet twin-jet 8002 nozzles at 20 psi in 20 gallons of water per acre.
- **Fall applications of Contans:** Applications were made from 10:30 am to 12:30 pm on October 11, 2011 (soil temperature: 52 to 56°F, wind speed: 5.2 to 7.9 miles per hr, air temperature: 56 to 65°F, relative humidity: 71-62%). Contans was incorporated both manually and with water. Harrowing (to 1.5 inches) was conducted from 1:15 to 2:30 pm; the non-treated controls were harrowed first. An inch of water was applied to the via overhead center pivot irrigation over a 24-hour period starting at 3:00 pm on Oct. 11.
- **Spring applications of Contans:** Applications were made from 10:45 am to 1:15 pm on April 24, 2012 (soil temperature: 52 to 56°F, wind speed: 12.6 to 14.7 miles per hr, air temperature: 68 to 74°F, relative humidity: 40-28%). Harrowing (to 1.5 inches) was conducted from 11:40 am to 1:40 pm; the non-treated controls were harrowed first. An inch of water was applied to the via overhead center pivot irrigation over a 24-hour period starting at 1:15 pm on April 24.
- **Irrigation:** To promote apothecial development and disease establishment, the soybeans were irrigated such that they received 1 to 1.5 inches of water per week (including rainfall events) from 10 days prior to bloom initiation until the R7 growth stage (at least one pod per plant has reached its mature color).
- **Assessments of Sclerotinia incidence, apothecia, and carpogenically germinated sclerotia:** The experiment evaluating fall versus spring applications was assessed August 27 to 29 and August 31 at the R6 growth stage (full seed; at least one pod at the four uppermost nodes contain green seeds that fill the pod capacity). ** In each plot, apothecia and carpogenically germinated sclerotia were assessed in five 0.76 x 1.00 meter rectangles arranged in an X-pattern (a total of 3.81 square meters per plot). Leaves and other debris were carefully removed from the soil surface to expose all apothecia. All isolated apothecia or clusters of apothecia were assumed to originate from different sclerotia, and all dense clusters of apothecia were assumed to originate from a single sclerotium. ** Sclerotinia stem rot was assessed on the 0 to 3 scale developed by Craig Grau at the University of Wisconsin: 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, 225 plants were evaluated (45 plants in each of 5 locations per plot). No differences in disease severity were observed across treatments, and only disease incidence is reported.
- **Harvest:** The trial was harvested on October 10 (replicates 1, 3, and 4) and October 11 (replicates 2, 5, and 6). The remainder of the field (including the soybeans between the treatment plots) was harvested on Sept. 21 and 24.
- **Statistical analysis:** Analysis of variance was conducted PROC GLM of SAS (Version 9.2; SAS Institute, Cary, NC). 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. To meet model assumptions, systematic natural-log transformations were applied to the Sclerotinia incidence and apothecia data [LN(x) for data sets with no values below 1.0; otherwise, LN(x+1)]. For the split-plot designs, customized F-tests were constructed for the main effect using replicate by treatment interaction for the error term. Split-plot designs were analyzed with replicate, main factor, main factor by replicate interaction, sub-factor, and sub-factor by main-factor interaction in the model.

FUNDING:

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

IMPORTANT NOTICE:

- The performance of products such as Contans can differ in response to which diseases are present, levels of sclerotia in the soil, distribution of sclerotia in the soil, environmental conditions, plant architecture and the susceptibility to disease of the soybean variety planted, timing of application, and other factors.
- This report summarizes the performance of Contans as tested at the NDSU Carrington Research Extension Center in 2012 under the conditions partially summarized in the methods section (above).
- The performance of Contans may differ under other conditions; when evaluating products, always evaluate results from multiple trials.
- This report is shared for educational purposes and is not an endorsement of any specific products.