

Field evaluation Contans for management of Sclerotinia stem rot on soybeans: Evaluation of spring application timing

Carrington, ND (2012)

Michael Wunsch, Michael Schaefer, and Billy Kraft
North Dakota State University Carrington Research Extension Center

KEY FINDINGS:

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

- **Application timing in the spring had little effect on the efficacy of Contans.** Contans performed similarly when applied 38, 31, 24, 17, 10, and 2 days prior to planting soybeans. Soybeans were planted May 11.
- **Springtime applications had a greater impact on apothecia production than on the viability of the sclerotia.** When applied in the spring, Contans did not appear to have enough time to fully degrade the large sclerotia (originating from a sunflower crop) before the summer. However, it caused individual sclerotia to produce fewer apothecia.

The effect of Contans applications on Sclerotinia 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 springtime applications of Contans may reduce apothecial production by Sclerotinia, thereby reducing disease pressure. There may be considerable latitude in choosing an application timing in the spring. Stakeholders are cautioned that sclerotia were primarily on the soil surface in this trial. Similar results would be expected when Contans is applied directly to crop residues and sclerotia after a white-mold-infested crop is harvested (before tillage operations are conducted).

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:

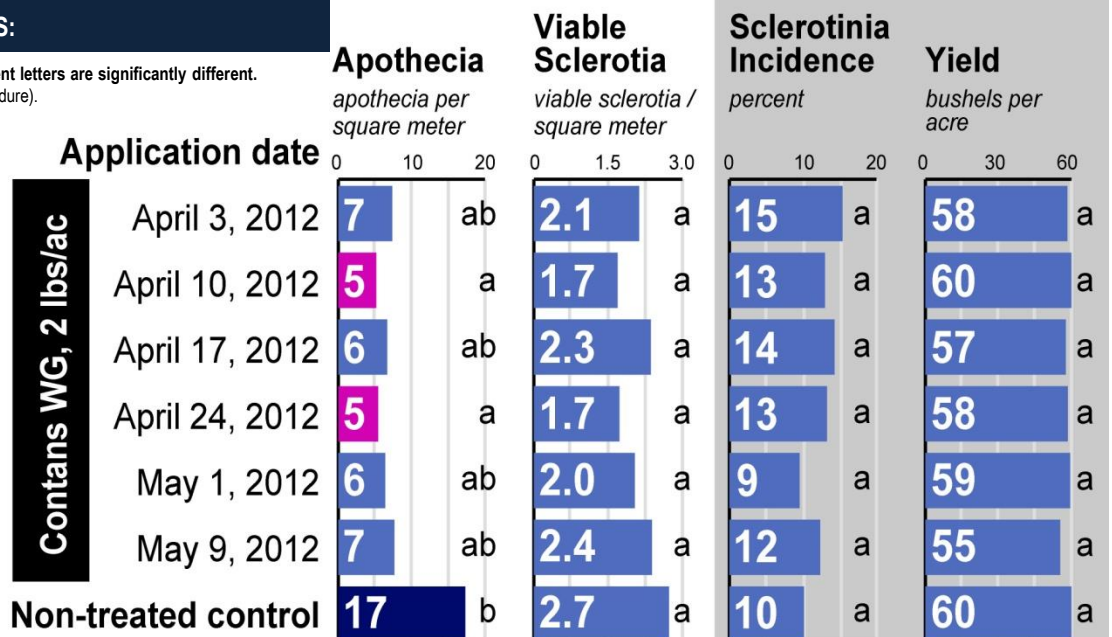


SUMMARY OF KEY RESULTS:

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.



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DETAILED RESULTS:

TREATMENT & APPLICATION RATE	DATE OF TREATMENT IMPOSITION	INCORPORATION METHOD ^{x,y}	CARGOGENICALLY 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	
			Sept. 2-5 ^w	Sept. 2-5 ^w	Sept. 2-5 ^w	13% moisture	13% moisture	13% moisture	
1 Contans 2 lbs/ac	April 3, 2012	manual incorporation ^y	7 ab*	2.1 a*	15 a*	58 a*	58.9 a*	2897 a*	
2 Contans 2 lbs/ac	April 10, 2012	manual incorporation	5 a	1.7 a	13 a	60 a	58.8 a	2765 a	
3 Contans 2 lbs/ac	April 17, 2012	manual incorporation	6 ab	2.3 a	14 a	57 a	58.9 a	2851 a	
4 Contans 2 lbs/ac	April 24, 2012	manual + water incorporation ^x	5 a	1.7 a	13 a	58 a	59.5 a	2848 a	
5 Contans 2 lbs/ac	May 1, 2012	manual incorporation	6 ab	2.0 a	9 a	59 a	58.9 a	2879 a	
6 Contans 2 lbs/ac	May 9, 2012	manual incorporation	7 ab	2.4 a	12 a	55 a	58.8 a	2911 a	
7 Control (no Contans)	April 24, 2012	manual incorporation	17 b	2.7 a	10 a	60 a	58.7 a	2885 a	
			F:	3.20	0.81	0.78	0.60	0.11	1.86
			P>F:	0.0161	0.5717	0.5954	0.7281	0.9951	0.1240
			CV:	28.6	48.0	30.9	9.6	3.4	3.1
8 Contans 4 lbs/ac	April 3, 2012	manual incorporation	5 a*	2.3 a*	16 a*	58.1 a*	58.8 a*	2874 a*	
9 Contans 4 lbs/ac	April 10, 2012	manual incorporation	4 a	2.2 a	10 a	61.9 a	58.9 a	2857 a	
10 Contans 4 lbs/ac	April 17, 2012	manual incorporation	8 a	2.5 a	14 a	57.2 a	58.8 a	2897 a	
11 Contans 4 lbs/ac	April 24, 2012	manual + water incorporation	4 a	2.0 a	14 a	54.3 a	58.9 a	2774 a	
12 Contans 4 lbs/ac	May 1, 2012	manual incorporation	4 a	1.9 a	12 a	56.9 a	58.5 a	2872 a	
13 Contans 4 lbs/ac	May 9, 2012	manual incorporation	5 a	2.0 a	12 a	59.0 a	58.6 a	2832 a	
14 Control (no Contans)	April 24, 2012	manual incorporation	9 a	2.5 a	15 a	53.1 a	58.6 a	2849 a	
			F:	1.39	0.27	0.69	1.10	0.74	1.11
			P>F:	0.2539	0.9484	0.6572	0.3598	0.6206	0.3807
			CV:	33.3	57.0	22.5	11.6	0.7	3.2

^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 Sept. 2 to 5 was R7** (beginning maturity; at least one pod on the main stem has reached its mature color).

* **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 disease incidence and apothecia [LN(x + 1)]. For ease of interpretation, treatment means are reported as the (untransformed) disease incidence and number of apothecia.**

	df	SS	MS	F	P > F
Total (subplots)	83	45.10			
Replicate	5	13.79	2.75	5.75	0.0388
Application Rate (A)	1	0.32	0.32	0.67	0.4511
Error A (Rep * A)	5	2.40	0.48		
Applic. Timing (B)	6	1.55	0.26	0.62	0.7110
Interaction (A*B)	6	2.16	0.36	0.87	0.5247
Error B	60	24.88	0.41		

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

	df	SS	MS	F	P > F
Total (subplots)	83	35.49			
Replicate	5	0.69	0.14	0.88	0.5549
Application Rate (A)	1	1.20	1.20	7.65	0.0396
Error A (Rep * A)	5	0.78	0.16		
Applic. Timing (B)	6	7.21	1.20	2.99	0.0127
Interaction (A*B)	6	1.51	0.25	0.62	0.7097
Error B	60	24.11	0.40		

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

	df	SS	MS	F	P > F
Total (subplots)	83	96.45			
Replicate	5	4.89	0.98	0.67	0.6654
Application Rate (A)	1	0.08	0.08	0.06	0.8223
Error A (Rep * A)	5	7.32	1.46		
Applic. Timing (B)	6	5.68	0.95	0.74	0.6184
Interaction (A*B)	6	1.85	0.31	0.24	0.9611
Error B	60	76.63	1.28		

	df	SS	MS	F	P > F
Total (subplots)	83	3364.9			
Replicate	5	439.2	87.7	1.42	0.3538
Application Rate (A)	1	14.0	14.0	0.23	0.6538
Error A (Rep * A)	5	308.5	61.7		
Applic. Timing (B)	6	186.9	31.1	0.85	0.5334
Interaction (A*B)	6	229.7	38.3	1.05	0.4024
Error B	60	1178.2	51.2		

	df	SS	MS	F	P > F
Total (subplots)	83	176.49			
Replicate	5	14.39	2.88	1.26	0.4025
Application Rate (A)	1	0.75	0.75	0.33	0.5910
Error A (Rep * A)	5	11.41	2.28		
Applic. Timing (B)	6	2.44	0.41	0.17	0.9846
Interaction (A*B)	6	0.90	0.15	0.06	0.9990
Error B	60	146.59	2.44		

	df	SS	MS	F	P > F
Total (subplots)	83	748783			
Replicate	5	200890	40178	7.80	0.0208
Application Rate (A)	1	2754	2754	0.53	0.4974
Error A (Rep * A)	5	25752	5150		
Applic. Timing (B)	6	71716	11953	1.9	0.0956
Interaction (A*B)	6	70189	11698	1.86	0.1028
Error B	60	377482	6291		

Interpretation of ANOVA tables:

- The application rate of Contans (2 vs. 4 lbs/ac) had a significant effect on the number of apothecia produced. It did not have a significant effect on the number of viable (carpogenically germinated) sclerotia produced below the soybean canopy, Sclerotinia incidence, soybean yield, test weight, or kernel weight.
- There were significant differences in apothecia production but not disease incidence, viable (carpogenically germinated) sclerotia, yield, test weight, or kernel weight among Contans treatments (non-treated control and Contans applied 2, 10, 17, 24, 31, or 38 days prior to planting).
- The relative performance of the different Contans treatments (non-treated control and Contans applied 2, 10, 17, 24, 31, or 38 days prior to planting) was similar irrespective of application rate (2 vs. 4 lbs/ac) at which Contans was applied; there were no significant interaction effects between application rate of Contans and the performance of the different Contans treatments (non-treated control and Contans applied 2, 10, 17, 24, 31, or 38 days prior to planting).

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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 springtime application timing experiment was arranged as a completely randomized split-plot design; a completely randomized block design was used for the main factor. Application rate (2 lbs/ac vs. 4 lbs/ac) was the main factor, and application timing (2, 10, 17, 24, 31, or 38 days prior to planting) was the sub-factor. For results from the 4 lb/ac application rate, see the full (technical) report.
- **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. An additional 18 grams of sclerotia were applied to the surface of plots on March 30, 2012. 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.
- **Specifics for each Contans application:** (1) April 3, 2012. Applications were made from 10:30 am to 12:00 pm (soil temperature: 42 to 45°F, wind speed: 9.1 to 9.8 miles per hr, air temperature: 50 to 54°F, relative humidity: 45-35%). Harrowing (to 1.5 inches) was conducted from 11:45 am to 12:05 pm. (2) April 10, 2012. Applications were made from 2:30 to 3:30 pm (soil temperature: 45°F, wind speed: 10.9 miles per hr, air temperature: 39°F, relative humidity: 39%). Harrowing (to 1.5 inches) was conducted from 3:40 to 4:10 pm. (3) April 17, 2012. Applications were made from 10:00 to 10:30 am (soil temperature: 39°F, wind speed: 15.1 miles per hr, air temperature: 43°F, relative humidity: 78%). Harrowing (to 1.5 inches) was conducted from 10:40 to 11:10 am. (4) April 24, 2012. Applications were made from 10:45 am to 1:15 pm (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. (5) May 1, 2012. Applications were made from 11:15 to 11:45 am (soil temperature: 54°F, wind speed: 3.5 miles per hour, air temperature: 67°F, relative humidity: 62%). Harrowing (to 1.5 inches) was conducted from 12:15 to 12:45 pm. (6) May 9, 2012. Applications were made from 10:00 to 10:30 am (soil temperature: 49°F, wind speed: 9.7 miles per hr, air temperature: 57°F, relative humidity: 58%). Harrowing (to 1.5 inches) was conducted from 11:00 to 11:30 am.
- **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 spring application timing of Contans was assessed September 2 to 5 at the R7 growth stage (beginning maturity; at least one pod on the main stem has reached its mature color). ** 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 11 (replicates 4 and 6) and October 12 (replicates 1, 2, 3, and 5). 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)]. All other datasets met model assumptions. 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.