

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

Carrington, ND (2012)

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KEY FINDINGS:

- Omega (fluazinam) and Topsin (thiophanate-methyl) performed well. Neither are currently registered on lentils.
- Additional testing will be needed to evaluate whether fungicides currently registered on lentils provide satisfactory control of Sclerotinia stem rot.
- Foliar applications of Omega (fluazinam) and Endura (boscalid) resulted in modest improvements in seed grade.

RESULTS – DISEASE CONTROL, YIELD, TEST WEIGHT, and KERNEL WEIGHT

The fungicides INSPIRE / BRAVO TOP, OMEGA, and QUASH are currently not registered for use on lentils and should not be used. Future registration of some of these fungicides is anticipated, and results for these products are provided for reference only.

Within-column means followed by different letters are significantly different

($P < 0.05$; Tukey multiple comparison procedure).

Treatment (Fungicide application timing) ^v	Sclerotinia severity ^{z†} July 11 ^w percent	Anthrachnose severity ^{y‡} July 11 ^w percent	Total necrosis ^{x‡} July 23 ^w percent	Test weight 13% moisture lbs/bu	Yield 13% moisture lbs/ac	Seeds per Pound seeds
1 Non-treated check (water)	15 cd *	1 ab	63 c *	60.3 cd *	2277 c *	9861 ab*
2 Omega 500F 13.6 fl oz/ac (A,B)	1 a	4 ab	20 a	61.0 abc	3051 ab	9354 ab
3 Omega 500F 16 fl oz/ac (A,B)	1 ab	2 ab	14 a	61.3 a	2824 abc	9149 a
4 Omega 500F 16 fl oz/ac (A) / Endura 70WG 6 oz/ac (B)	1 ab	5 b	21 ab	61.0 ab	3207 a	9177 ab
5 Non-treated check (water; A) / Endura 70WG 6 oz/ac (B)	20 d	1 ab	58 c	60.0 d	2159 c	9550 ab
6 Topsin 4.5FL 40 fl oz/ac (A,B)	3 abc	4 ab	22 ab	60.6 bcd	3070 ab	9425 ab
7 Xemium 2.23 fl oz/ac (A,B)	11 bcd	1 ab	53 c	60.6 bcd	2616 abc	9527 ab
8 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	6 a-d	2 ab	53 c	60.3 cd	2465 bc	9850 ab
9 Endura 70WG 6 oz/ac (A,B)	5 a-d	2 ab	38 bc	60.7 abc	2648 abc	9399 ab
10 Proline 480SC 5 oz/ac + NIS 0.125% v/v (A,B)	10 bcd	0 ab	49 c	60.6 bcd	2661 abc	9614 ab
11 Inspire 250EC 6.4 fl oz/ac + Bravo WeatherStik 22.3 fl oz/ac (A,B) ^u	15 cd	1 ab	63 c	60.7 abc	2483 abc	9670 ab
12 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	17 cd	0 a	61 c	60.4 bcd	2256 c	9983 b
	F: 8.30	2.91	18.71	7.29	5.58	2.34
	P > F: < 0.0001	0.0140	< 0.0001	< 0.0001	0.0003	0.0395
	CV: 33.3	84.3	7.1	0.4	10.9	3.6

^z Sclerotinia: Percent of the canopy exhibiting Sclerotinia symptoms and/or plant mortality caused by Sclerotinia stem rot.

^y Anthracnose: Percent of the canopy exhibiting anthracnose symptoms and/or plant mortality caused by anthracnose.

^x Total necrosis: Percent of the canopy exhibiting symptoms of Sclerotinia stem rot or anthracnose and plant mortality caused by Sclerotinia stem rot or anthracnose. No other diseases were present above trace levels.

^w Lentils were at mid pod-fill on July 11 and late pod-fill on July 23.

^v Fungicide application timing:

Application A: June 29, 2012 at 7:00 - 8:00 am; canopy closure, lentils at full bloom (approx. 8 to 10 days after bloom initiation); no foliar disease present; wind = 3-6 mph out of the west, temperature = 62-68°F, relative humidity = 66-82%.

Application B: July 11, 2012 at 6:00-7:30 am; see disease ratings for disease levels; wind = 4-6 mph out of the southeast, temperature = 69-73°F, relative humidity = 75-78%.

^u Applied to approximate the performance of Bravo Top 4.59SC. Syngenta had insufficient supplies of Bravo Top available for testing. To obtain preliminary information on the potential performance of Bravo Top, the component ingredients of Bravo Top (difenoconazole and chlorothalonil) were evaluated by tank-mixing Inspire and Bravo WeatherStik.

* 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 disease severity [LN(x + 1) for data sets with values below 1.0; LN(x) for data sets with no values below 1.0]. For ease of interpretation, treatment means are reported as disease severity.

TO ASSESS FUNGICIDE EFFICACY AGAINST SCLEROTINIA WHILE MINIMIZING THE COUNFOUNING INFLUENCE OF OTHER DISEASES,

the fungicide Headline (pyraclostrobin) was applied across all plots (including the non-treated control) on June 21 (bloom initiation; 6 fl oz/ac), July 3 (6 fl oz/ac), and July 12 (8 fl oz/ac). Headline has efficacy against anthracnose, Ascochyta, and other foliar diseases but not Sclerotinia.

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RESULTS – SEED QUALITY

The fungicides **INSPIRE / BRAVO TOP, OMEGA, and QUASH** are currently not registered for use on lentils and should not be used. Future registration of some of these fungicides is anticipated, and results for these products are provided for reference only.

Treatment (Fungicide application timing) ^v	SEED QUALITY								
	Viable seeds ^u percent	Split & broken ^{t‡} percent	Diseased ^s percent	Stained ^r percent	Discolored (Total) ^q percent	Wrinkled ^p percent	Sclerotia ^p percent	Grade - US ⁿ 1 to 4	Grade - Canada ^m 1 to 5
1 Non-treated check (water; A,B)	90.4 b*	1.9 a*	3.3 a*	6.6 a*	9.9 a*	17.0 a*	0.03 a*	4	4
2 Omega 500F 13.6 fl oz/ac (A,B)	94.5 ab	1.4 a	2.2 a	5.0 a	7.3 a	13.3 a	0.01 a	3	3
3 Omega 500F 16 fl oz/ac (A,B)	95.6 a	1.0 a	1.8 a	5.1 a	6.9 a	13.6 a	0.01 a	3	3
4 Omega 500F 16 fl oz/ac (A) / Endura 70WG 6 oz/ac (B)	94.8 ab	0.6 a	3.1 a	6.7 a	9.8 a	15.5 a	0.02 a	3	3
5 Non-treated check (water; A) / Endura 70WG 6 oz/ac (B)	90.6 ab	1.2 a	2.5 a	7.2 a	9.7 a	18.9 a	0.02 a	3	4
6 Topsin 4.5FL 40 fl oz/ac (A,B)	93.2 ab	1.8 a	3.6 a	7.0 a	10.6 a	16.6 a	0.03 a	4	4
7 Xemium 2.23 fl oz/ac (A,B)	94.0 ab	1.2 a	2.9 a	5.5 a	8.4 a	17.4 a	0.03 a	3	4
8 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	93.0 ab	1.5 a	3.1 a	6.6 a	9.7 a	16.9 a	0.01 a	3	4
9 Endura 70WG 6 oz/ac (A,B)	93.6 ab	1.2 a	2.6 a	5.8 a	8.3 a	13.6 a	0.04 a	3	3
10 Proline 480SC 5 oz/ac + NIS 0.125% v/v (A,B)	94.4 ab	1.2 a	3.9 a	6.2 a	10.1 a	17.6 a	0.02 a	4	4
11 Inspire 250EC 6.4 fl oz/ac + Bravo WeatherStik 22.3 fl oz/ac (A,B) ^k	91.5 ab	1.1 a	3.0 a	7.3 a	10.3 a	15.9 a	0.04 a	3	4
12 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	91.7 ab	2.4 a	4.1 a	7.6 a	11.7 a	18.7 a	0.02 a	4	4
	F: 2.52	1.61	1.27	0.70	1.10	0.91	0.91		
	P > F: 0.0281	0.1610	0.3009	0.7266	0.4044	0.5452	0.5472		
	CV: 2.3	35.8	39.7	32.8	28.5	24.8	88.2		

^v Fungicide application timing:

Application A: June 29, 2012 at 7:00 - 8:00 am; canopy closure, lentils at full bloom (approx. 8 to 10 days after bloom initiation); no foliar disease present; wind = 3-6 mph out of the west, temperature = 62-68°F, relative humidity = 66-82%.

Application B: July 11, 2012 at 6:00-7:30 am; see disease ratings for disesae levels; wind = 4-6 mph out of the southeast, temperature = 69-73°F, relative humidity = 75-78%.

^u **Viable seeds:** Germination rate; assessed as the percent of 246 to 250 lentils that germinated in 10 to 12 days in a standard germination assay.

^t **Split & broken:** The percent (by weight) of lentils in which cotyledons are separated or held together loosely (split lentils) or one-quarter or more of the complete lentil is broken (broken lentils).

^s **Diseased:** Lentils with large dark colored lesions or obvious fungal growth on seed coat.

^r **Stained:** Lentils with mottling, small dark-colored spots, or water spots (distinct light brown discoloration) on seed coat.

^q **Discolored (total):** The combined total of diseased and stained seeds.

^p **Wrinkled:** The percent (by weight) of lentils exhibiting sharp ridges and depressions in the seed coat. Lentils with a dimpled seed coat or folds restricted to the outside ring of the seed were excluded.

ⁿ **Grade - US:** A 1 to 4 scale in which 1 = U.S. Grade No. 1 lentils, 2 = U.S. Grade No. 2 lentils, 3 = U.S. Grade No. 3 lentils, and 4 = U.S. Sample Grade lentils.

^m **Grade - Canada:** A 1 to 5 scale in which 1 = No. 1 Canada lentils, 2 = No. 2 Canada lentils, 3 = Extra No. 3 Canada lentils, 4 = No. 3 Canada lentils, and 5 = Sample Canada lentils (due to damage).

^k **Applied to approximate the performance of Bravo Top 4.59SC.** Syngenta had insufficient supplies of Bravo Top available for testing. To obtain preliminary information on the potential performance of Bravo Top, the component ingredients of Bravo Top (difenoconazole and chlorothalonil) were evaluated by tank-mixing Inspire and Bravo WeatherStik.

* **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 split and broken seeds** [$\text{LN}(x + 1)$]. For ease of interpretation, treatment means are reported as the untransformed percent split and broken seeds.

TO ASSESS FUNGICIDE EFFICACY AGAINST SCLEROTINIA WHILE MINIMIZING THE COUNFOUNDING INFLUENCE OF OTHER DISEASES,

the fungicide Headline (pyraclostrobin) was applied across all plots (including the non-treated control) on June 21 (bloom initiation; 6 fl oz/ac), July 3 (6 fl oz/ac), and July 12 (8 fl oz/ac). Headline has efficacy against anthracnose, Ascochyta, and other foliar diseases but not Sclerotinia.

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METHODS – Agronomics and statistical analysis:

- **Location of trial:** NDSU Carrington Research Extension Center, Carrington, ND.
- **GPS coordinates of research trial location:** 47.510302,-99.132842
- **Variety:** CDC 'Richlea' (a medium-green lentil)
- **Experimental design:** randomized complete block **Replicates:** 4
- **Seeded plot size:** 5 feet wide (center-to-center) x 25 feet long **Harvested plot size:** 5 feet wide (center-to-center) x approx. 19 feet long
- **Row spacing:** 7 inches **Rows per plot:** 7
- **Non-treated buffer plots were established between treatment plots.**
- **Previous crop:** soybean
- **Planting date:** May 2, 2012 **Seeding rate:** 18 pure live seeds per square foot
- **Seed treatment:** Cruiser 5FS 1.28 fl oz/cwt + ApronMaxxRTA 5.0 fl oz/cwt + Mertect 340F 1.05 fl oz/cwt
- **Rhizobium inoculant:** "Nodulator" peat-based granular inoculant for peas and lentils (*Rhizobium leguminosarum*; Becker Underwood, St Joseph, MO); applied at the commercially recommended rate of 6 oz/1000 feet of row.
- **Fungicide application A:** June 29, 2012 at 7:00 - 8:00 am; canopy closure, lentils at full bloom (approx. 8 to 10 days after bloom initiation); no foliar disease present. Wind = 3-6 mph out of the west, temperature = 62-68°F, relative humidity = 66-82%.
- **Fungicide application B:** July 11, 2012 at 6:00-7:30 am; see disease ratings for disease levels. Wind = 4-6 mph out of the southeast, temperature = 69-73°F, relative humidity = 75-78%.
- **Fungicide application details:** Fungicides were applied with a 60-inch hand boom equipped with four equally spaced Spraying Systems TeeJet XR 8001VS flat-fan nozzles at a spray volume of 17.5 gal water/acre operated at 35 psi.
- **Sclerotinia inoculation details:** Sclerotia (resting structures) of *Sclerotinia sclerotiorum*, causal agent of Sclerotinia stem rot, were distributed across the trial in May 2011 (one year prior to seeding), and additional overwintered sclerotia were distributed across the trial on April 23, 2012 (immediately prior to seeding; 0.0874 grams of sclerotia per square foot). The trial was also inoculated with laboratory-produced ascospores of *S. sclerotiorum* on July 4 at 1:00 to 2:00 am. Spores were applied with a 60-inch hand boom with four equally spaced 8003 twinjet nozzles at a spray volume of 26 gallons/ac and operated at 20 psi. The spore concentration utilized was 2,000 spores/ml, and 3,250 spores were applied per square foot.
- **TO PERMIT THE ASSESSMENT OF FUNGICIDE EFFICACY AGAINST SCLEROTINIA WITHOUT THE CONFOUNDING INFLUENCE OF OTHER DISEASES,** anthracnose and *Ascochyta* were controlled with Headline. Headline, which does not have efficacy against *Sclerotinia*, was applied across all plots (including the non-treated control) on June 21 (bloom initiation; 6 fl oz/ac), July 3 (6 fl oz/ac), and July 12 (8 fl oz/ac).
- **Disease assessments:** Anthracnose and *Sclerotinia* severity were assessed on July 11 as the percent of the plot exhibiting each disease. When the second disease assessment was conducted on July 23, anthracnose and *Sclerotinia* had caused considerable plant mortality, and it was no longer possible to accurately assign the cause of mortality to either disease. As a consequence, only total necrosis (caused by a combination of anthracnose and *Sclerotinia*) was recorded on July 23.
- **Irrigation:** To facilitate disease establishment, overhead irrigation was applied with a center pivot during bloom.
- **Harvest date:** August 6, 2012. The trial was swathed July 31, 2012.
- **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. To meet model assumptions, a systematic natural-log transformation $[\text{LN}(x+1)]$ for data sets including values below 1.0; $\text{LN}(x)$ for data sets in which no values were below 1.0] was applied to the disease severity data. All other 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, Tukey's 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).

WE GRATEFULLY ACKNOWLEDGE:

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We gratefully acknowledge **Becker Underwood** for donating the *Rhizobium* inoculant used in this trial, **Syngenta Crop Protection** for donating the seed treatment products Cruiser and Mertect, and **JM Grain** for helping us obtain seed of CDC Richlea lentils for use in this trial.

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 chickpea 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 in 2012 under the conditions partially summarized in the methods section (above).
- 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.

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METHODS - Seed quality assessments

Seed quality assessments:

- Viable seeds:** The viability of the harvested seeds was assessed as the percent of seeds that germinated in 10 to 12 days in a standard germination assay. From each plot, 246 to 250 seeds were evaluated.
- Split and broken seeds:** The percent (by weight) of lentils exhibiting cotyledons that were separated or held together loosely (split lentils) or having one-quarter or more of the seed broken (broken lentils). In each plot, all split and broken lentils encountered while counting 250 whole lentils were weighed.
- Diseased lentils:** The percent (by weight) of lentils exhibiting dark colored lesions or obvious fungal growth on the seed coat. From each plot, 250 whole lentils were assessed.
- Stained lentils:** The percent (by weight) of lentils exhibiting mottling, small dark-colored spots, or water spots (distinct light brown discoloration) on the seed coat. From each plot, 250 lentils were assessed.
- Discolored lentils:** The combined total of diseased and stained seeds.
- Wrinkled seeds:** The percent (by weight) of lentils exhibiting sharp ridges and depressions in the seed coat. Lentils with a dimpled seed coat or with folds restricted to the outside ring of the seed were excluded. From each plot, 250 lentils were assessed.
- U.S. Grade:** The U.S. grade of the lentils was determined on dockage-free lentils using the guidelines established by the USDA Grain Inspection, Packers, and Stockyards Administration. U.S. Grade No. 1 lentils exhibited less than 2% defective lentils (by weight; includes split and broken lentils and diseased lentils), less than 0.2% foreign material, less than 4% skinned lentils, and good color. U.S. Grade No. 2 lentils exhibited between 2 and 3.5% defective lentils, between 0.2 and 0.5% foreign material, between 4 and 7% skinned lentils, or fair color. U.S. Grade No. 3 lentils exhibited between 3.5 and 5.0% defective lentils, less than 0.5% foreign material, between 7 and 10% skinned lentils, or poor color. U.S. sample grade lentils exhibited more than 5% defective lentils, more than 0.5% foreign material, or more than 10% skinned lentils. The USDA does not provide strict guidelines on lentil color; for the purposes of this study, lentils exhibiting less than 1% (by weight) diseased seeds and less than 2.5% (by weight) stained seeds were considered to have "good" color, lentils exhibiting between 1 and 3.5% (by weight) diseased seeds or between 2.5 and 7% (by weight) stained seeds were considered to have "fair" color, lentils exhibiting more than 3.5% (by weight) diseased seeds or more than 7% (by weight) stained seeds were considered to have "poor" color. Grade assessments were made separately for each plot, and the grades assigned to each treatment represent the average grade observed across replicates of the experiment.
- Canadian grade:** The Canadian grade of lentils was determined on dockage-free lentils using the guidelines established by the Canadian Grain Commission. No. 1 Canada lentils exhibited less than 1% stained lentils (by weight, includes lentils exhibiting water spots and mottling); less than 2% peeled, split and broken lentils; less than 1% lentils damaged by disease or other causes; less than 2% total damaged lentils (peeled, split, broken, insect damaged, diseased, etc.); and having good natural color. No. 2 Canada lentils exhibited between 1 and 4% stained lentils; between 2 and 3.5% peeled, split and broken lentils; between 1 and 2% lentils damaged by disease or other causes; between 2 and 3.5% total damaged lentils (stained + disease or other causes); or having reasonably good natural color. Extra No. 3 Canada lentils exhibited between 4 and 7% stained lentils; between 3.5 and 5% peeled, split and broken lentils; between 2 and 5% lentils damaged by disease or other causes; between 3.5 and 5% total damaged lentils (stained + disease or other causes); or having fair color. No. 3 Canada lentils exhibited more than 7% stained lentils; between 5 and 10% peeled, split and broken lentils; between 5 and 10% lentils damaged by disease or other causes; between 5 and 10% total damaged lentils (stained + disease or other causes); or having poor color. Sample grade Canada lentils exhibited more than 10% peeled, split and broken lentils; more than 10% lentils damaged by disease or other causes; or more than 10% total damaged lentils (stained + disease or other causes). Grade assessments were made separately for each plot, and the grades assigned to each treatment represent the average grade observed across replicates of the experiment.



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