

Field evaluation of fungicides for management of anthracnose on lentils

Sykeston, ND (2012)

Michael Wunsch, plant pathologist

Michael Schaefer, research specialist

Billy Kraft, research technician

North Dakota State University Carrington Research Extension Center

KEY FINDINGS:

- Under severe anthracnose disease pressure, the registered fungicides **Headline** (pyraclostrobin), **Priaxor** (pyraclostrobin + fluxapyroxad), and **Quadris** (azoxystrobin) performed well.
- The efficacy of **Priaxor** appeared to be derived from the pyraclostrobin active ingredient. Priaxor is a premix of pyraclostrobin and fluxapyroxad, the active ingredients in Headline and Xemium, respectively. Headline performed well in this trial, and Xemium did not.
- When registered, **Omega** (fluazinam) and **Bravo Top** (difenoconazole + chlorothalonil) may be useful tools for managing anthracnose.
- Use of the most effective foliar fungicides resulted in modest improvements in seed quality.

RESULTS:

Disease control, yield, test weight, and kernel weight

Treatment (Fungicide application timing) ^w	Anthracnose severity ^{z†}	Sclerotinia severity ^{y†}	Test weight	Yield	Seeds per pound
	July 28 ^x percent	July 28 ^x percent	13% moisture lbs/bu	13% moisture lbs/ac	seeds
1 Non-treated check (water)	79 b *	2 ab *	55.3 def	1532 e *	10168 ab
2 Omega 500F 13.6 fl oz/ac (A,B)	1 a	0 ab	57.2 a-d	2538 ab	9622 ab
3 Omega 500F 16 fl oz/ac (A,B)	2 a	1 ab	56.8 a-e	2356 abc	9416 a
4 Omega 500F 16 fl oz/ac (A) / Headline 250SC 6 fl oz/ac (B)	2 a	0 ab	57.5 abc	2339 abc	9277 a
5 Non-treated check (water; A) / Headline 250SC 6 fl oz/ac (B)	2 a	4 ab	57.5 abc	2244 a-d	9640 ab
6 Headline 250SC 6 fl oz/ac (A,B)	1 a	2 ab	57.9 abc	2206 a-e	9424 a
7 Xemium 2.23 fl oz/ac (A,B)	79 b	6 b	55.0 ef	1853 b-e	10747 b
8 Xemium 3.34 fl oz/ac (A,B)	79 b	3 ab	55.9 c-f	1667 de	10324 ab
9 Priaxor 500SC 4 fl oz/ac (A,B)	1 a	1 ab	57.7 ab	2160 a-e	9304 a
10 Priaxor 500SC 6 fl oz/ac (A,B)	0 a	1 ab	58.0 a	2660 a	9172 a
11 Priaxor 500SC 4 fl oz/ac (A) / Proline 480SC 5.7 fl oz/ac + NIS 0.25% v/v 0.125% v/v (B)	0 a	1 ab	57.5 abc	2383 abc	9050 a
12 Proline 480SC 5 oz/ac + NIS 0.125% v/v (A,B)	70 b	0 a	56.4 a-e	1707 cde	9502 a
13 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	50 b	2 ab	56.6 a-e	1747 b-e	9731 ab
14 Endura 70WG 6 oz/ac (A,B)	84 b	1 ab	55.9 b-f	1709 cde	10136 ab
15 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	89 b	3 ab	54.3 f	1593 de	10165 ab
16 Inspire 250EC 6.4 fl oz/ac + Bravo WeatherStik 22.3 fl oz/ac (A,B) ^v	1 a	4 ab	57.0 a-d	2170 a-e	9222 a
17 Quadris 250SC 6.2 fl oz/ac (A,B)	3 a	4 ab	57.2 abc	1824 b-e	9759 ab
18 Aproach 2.08SC 12 oz/ac + NIS 0.125% v/v (A,B)	19 b	1 ab	56.6 a-e	2091 a-e	9511 a
	F: 31.65	2.33	9.03	7.43	3.96
	P > F: < 0.0001	0.0185	< 0.0001	< 0.0001	0.0003
	CV: 30.0	92.0	1.2	12.2	4.6

^z Anthracnose: Percent of the canopy with anthracnose symptoms and/or exhibiting plant mortality caused by anthracnose.^y Sclerotinia: Percent of the canopy with Sclerotinia symptoms and/or exhibiting plant mortality caused by Sclerotinia stem rot. These data should be interpreted cautiously. Sclerotinia stem rot began developing after anthracnose, and development of Sclerotinia stem rot was reduced in treatments with severe anthracnose pressure.^x Lentils were at mid pod-fill on July 11 and late pod-fill on July 20.^w Fungicide application timings A and B:**Application A:** June 29, 2012 at 11:00 am - 1:00 pm; canopy closure, lentils at full bloom (approx. 8 to 10 days after bloom initiation); no foliar disease present. Wind = 4-6 mph out of the north to northwest, temperature = 78-82°F, relative humidity = 32-43%.**Application B:** July 11, 2012 at 6:30-8:00 am; no foliar disease present above trace levels. Wind = 4-6 mph out of the southeast, temperature = 69-75°F, relative humidity = 72-78%.^v 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 ease of interpretation, treatment means are reported as disease severity.

The fungicides APROACH, INSPIRE / BRAVO TOP, OMEGA, QUASH, and XEMIUM 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.

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701-652-2951 / michael.wunsch@ndsu.edu

RESULTS - SEED QUALITY:

Treatment (Fungicide application timing) ^w	SEED QUALITY								
	Protein 13% moisture percent	Viable seeds ^v percent	Split & broken ^u percent	Diseased ^t percent	Stained ^s percent	Discolored (Total) ^r percet	Wrinkled ^q percent	Grade - US ^p 1 to 4	Grade - Canada ⁿ 1 to 5
1 Non-treated check (water)	23.3 a *	83 a *	4.8 a *	6.8 ab*	8.7 ab*	15.4 ab*	17.0 abc	4	5
2 Omega 500F 13.6 fl oz/ac (A,B)	23.0 a	85 a	4.2 a	6.5 ab	7.1 ab	13.6 ab	14.7 abc	4	4
3 Omega 500F 16 fl oz/ac (A,B)	23.4 a	83 a	4.4 a	6.6 ab	7.3 ab	14.0 ab	15.1 ab	4	5
4 Omega 500F 16 fl oz/ac (A) / Headline 250SC 6 fl oz/ac (B)	23.5 a	87 a	3.6 a	4.8 ab	4.8 a	9.7 a	14.7 ab	4	4
5 Non-treated check (water; A) / Headline 250SC 6 fl oz/ac (B)	23.8 a	89 a	3.5 a	3.8 a	5.4 a	9.2 a	12.4 ab	4	4
6 Headline 250SC 6 fl oz/ac (A,B)	24.4 a	83 a	2.8 a	3.8 a	4.2 a	8.0 a	14.2 abc	4	4
7 Xemium 2.23 fl oz/ac (A,B)	22.7 a	82 a	5.2 a	8.4 ab	8.4 ab	16.8 ab	21.5 abc	4	5
8 Xemium 3.34 fl oz/ac (A,B)	23.5 a	78 a	3.8 a	8.0 ab	7.9 ab	15.9 ab	18.5 abc	4	5
9 Priaxor 500SC 4 fl oz/ac (A,B)	23.7 a	83 a	2.1 a	3.4 a	5.7 a	9.1 a	11.0 a	4	4
10 Priaxor 500SC 6 fl oz/ac (A,B)	24.2 a	82 a	3.0 a	4.6 a	3.7 a	8.3 a	12.3 ab	4	4
11 Priaxor 500SC 4 fl oz/ac (A) / Proline 480SC 5.7 fl oz/ac + NIS 0.25% v/v 0.125% v/v (B)	23.8 a	85 a	2.7 a	4.5 ab	5.1 ab	9.6 a	12.3 ab	4	4
12 Proline 480SC 5 oz/ac + NIS 0.125% v/v (A,B)	22.5 a	77 a	3.7 a	8.3 ab	8.6 ab	16.9 ab	17.9 abc	4	5
13 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	22.9 a	80 a	5.1 a	5.5 ab	6.3 ab	11.8 a	20.7 abc	4	5
14 Endura 70WG 6 oz/ac (A,B)	23.1 a	84 a	4.1 a	8.1 ab	8.3 ab	16.4 ab	24.8 bc	4	5
15 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	23.3 a	73 a	3.8 a	10.8 b	11.5 b	22.3 b	29.3 c	4	5
16 Inspire 250EC 6.4 fl oz/ac + Bravo WeatherStik 22.3 fl oz/ac (A,B) ^m	22.9 a	81 a	3.4 a	4.8 a	5.4 a	10.2 a	10.6 a	4	4
17 Quadris 250SC 6.2 fl oz/ac (A,B)	23.7 a	83 a	4.5 a	6.9 ab	7.0 ab	13.9 ab	16.8 abc	4	5
18 Aproach 2.08SC 12 oz/ac + NIS 0.125% v/v (A,B)	23.4 a	82 a	4.7 a	6.9 ab	6.4 ab	13.3 ab	17.3 abc	4	5
	F:	1.78	1.37	0.76	3.11	3.06	3.95	3.88	
	P > F:	0.0769	0.2166	0.7169	0.0025	0.0029	0.0004	0.0004	
	CV:	3.1	7.3	51.2	34.7	31.8	28.7	29.1	

^w Fungicide application timings A and B:

Application A: June 29, 2012 at 11:00 am - 1:00 pm; canopy closure, lentils at full bloom (approx. 8 to 10 days after bloom initiation); no foliar disease present. Wind = 4-6 mph out of the north to northwest, temperature = 78-82°F, relative humidity = 32-43%.

Application B: July 11, 2012 at 6:30-8:00 am; no foliar disease present above trace levels. Wind = 4-6 mph out of the southeast, temp. = 69-75°F, rel. humidity = 72-78%.

^v **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.

^u **Split & broken:** The percent (by weight) of lentils in which cotyledons are separated or held together loosely (split lentils), one-quarter or more of the complete lentil is broken (broken lentils), and/or three-quarters or more of seed coat has been removed (peeled/skinned lentils).

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

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

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

^q **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.

^p **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.

ⁿ **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).

^m **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 ease of interpretation, treatment means are reported as disease severity.

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UNDAMAGED

WRINKLED

STAINED

DISEASED

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METHODS – AGRONOMICS and STATISTICAL ANALYSIS:

- **Location of trial:** 2 miles southeast of Sykeston, ND
- **GPS coordinates of research trial location:** 47.4433, -99.3657
- **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:** buckwheat
- **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 11:00 am - 1:00 pm; canopy closure, lentils at full bloom (approx. 8 to 10 days after bloom initiation); no foliar disease present. Wind = 4-6 mph out of the north to northwest, temperature = 78-82°F, relative humidity = 32-43%.
- **Fungicide application B:** July 11, 2012 at 6:30-8:00 am; no foliar disease present above trace levels. Wind = 4-6 mph out of the southeast, temperature = 69-75°F, relative humidity = 72-78%.
- **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.
- **Inoculation details:** This trial was inoculated with *Botrytis cinerea*, cause of Botrytis gray mold, not with the pathogens causing anthracnose or Sclerotinia. However, anthracnose developed, most likely because the spray boom used to inoculate the trial and/or shoes and clothing worn in the trial were contaminated with the anthracnose pathogen. The high temperatures observed during the bloom period were favorable for anthracnose but not for Botrytis gray mold.
- **Irrigation:** To facilitate disease establishment, the trial was irrigated with rotating microsprinklers established on a 20 ft x 20 ft grid. On evenings when the trial was inoculated, 0.16 inches of water were applied; subsequent to inoculations, 0.08 inches of water were applied nightly for 4 to 5 nights.
- **Disease assessments:** Anthracnose and Sclerotinia severity were assessed on July 28 as the percent of the plot exhibiting each disease.
- **Harvest date:** August 14, 2012. The trial was swathed Aug. 1.
- **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:

This project was made possible with grants from the **Northern Pulse Growers Association** and the **North Dakota Department of Agriculture Crop Protection Product Harmonization Board and Registration Board**. Supplementary financial support was provided by the **BASF Corporation** and **ISK BioSciences**.

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 near Sykeston, ND 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 246 to 250 seeds that germinated in 10 to 12 days in a standard germination assay.
- **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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