

# Field evaluation of fungicides for management of anthracnose and Sclerotinia on lentils

Carrington, ND (2012)

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## KEY FINDINGS:

- Under a mixture of anthracnose and Sclerotinia disease pressure, the registered fungicides Headline (pyraclostrobin) and Priaxor (pyraclostrobin + fluxapyroxad) and the experimental fungicide Omega (fluazinam) 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.
- The use of the most effective foliar fungicides resulted in modest improvements in seed quality.

## RESULTS:

Disease control, yield, kernel weight, and test weight

The fungicides INSPIRE / BRAVO TOP, OMEGA, QUADRIS TOP, QUASH, and XEMIMUM are currently not registered for use on lentils and should not be used.

Future registration of some of these fungicides is anticipated, and results are provided for reference only.

Treatment (Fungicide application timing) <sup>v</sup>	Anthracnose severity <sup>z†</sup> July 11 <sup>w</sup> percent	Sclerotinia severity <sup>y†</sup> July 11 <sup>w</sup> percent	Total necrosis <sup>x†</sup> July 20 <sup>w</sup> percent	Test weight 13% moisture lbs/bu	Yield 13% moisture lbs/ac	Seeds per Pound seeds
1 Non-treated check (water)	36 efg *	8 bcd *	70 c *	57.4 d *	744 fg *	11587 cd *
2 Omega 500F 13.6 fl oz/ac (A,B) <sup>y</sup>	4 a-d	2 ab	29 ab	59.0 abc	1554 a-f	9888 a-d
3 Omega 500F 16 fl oz/ac (A,B)	2 abc	3 ab	21 a	59.4 a	1651 a-d	9722 a-d
4 Omega 500F 16 fl oz/ac (A) / Headline 250SC 6 fl oz/ac (B)	3 abc	2 ab	20 a	59.1 ab	1638 a-d	9077 a
5 Bravo WS 1.5 pt/ac (A) / Headline 250SC 6 fl oz/ac (B)	2 abc	17 d	49 bc	59.3 a	1483 a-f	9604 a-d
6 Headline 250SC 6 fl oz/ac (A,B)	0 a	8 bcd	29 ab	59.7 a	2130 a	9583 abc
7 Xemium 2.23 fl oz/ac (A,B)	45 fg	3 abc	79 c	57.5 d	671 g	11677 d
8 Priaxor 500SC 4 fl oz/ac (A,B)	1 ab	11 cd	26 a	59.5 a	1685 abc	9286 ab
9 Priaxor 500SC 6 fl oz/ac (A,B)	0 a	6 bcd	23 a	59.8 a	1951 ab	9288 ab
10 Priaxor 500SC 4 fl oz/ac (A) / Proline 480SC 5.7 fl oz/ac + NIS 0.125% v/v (B)	0 a	10 cd	25 a	59.5 a	1666 a-e	9607 a-d
11 Proline 480SC 5 fl oz/ac + NIS 0.125% v/v (A,B)	17 d-g	4 abc	74 c	58.0 d	891 fg	10963 a-d
12 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	29 efg	7 bcd	70 c	58.0 d	905 efg	11434 cd
13 Endura 70WG 6 oz/ac (A,B)	46 g	1 a	79 c	57.7 d	792 g	11105 a-d
14 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	39 efg	8 bcd	78 c	58.1 cd	822 d-g	11145 a-d
15 Inspire 250EC 6.4 fl oz/ac + Bravo WeatherStik 22.3 fl oz/ac (A,B) <sup>u</sup>	12 c-f	14 cd	55 c	59.3 a	1151 c-g	10009 a-d
16 Quadris Top 8 fl oz/ac + NIS 0.125% v/v (A,B)	2 abc	22 d	58 c	59.1 abc	1235 b-g	9831 a-d
17 Quadris 250SC 6.2 fl oz/ac (A,B)	3 a-d	19 d	54 c	59.2 a	1282 c-g	11252 bcd
18 Approach 2.08SC 12 fl oz/ac + NIS 0.125% v/v (A,B)	11 b-e	7 bcd	59 c	58.3 bcd	991 d-g	10721 a-d
	F: 19.62	10.05	24.79	25.29	11.13	5.17
	P > F: < 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	CV: 36.1	25.4	5.6	0.5	18.7	7.6

<sup>z</sup> Anthracnose: Percent of the canopy with anthracnose symptoms and/or exhibiting plant mortality caused by anthracnose.

<sup>y</sup> 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 approximately 10 to 14 days after first anthracnose developed; in many of the treatments, development of Sclerotinia stem rot was reduced due to severe anthracnose pressure.

<sup>x</sup> Total necrosis: Percent of the canopy with exhibiting plant mortality caused by a combination of anthracnose and/or Sclerotinia stem rot. No other diseases were present above trace levels.

<sup>w</sup> Lentils were at mid pod-fill on July 11 and late pod-fill on July 20.

<sup>v</sup> Fungicide application timings A and B:

**Application A:** June 22, 2012 at 6:30-7:30 am; 90% of plants with an open blossom; anthracnose symptoms present at low levels in the inoculated buffer plots but not the non-inoculated treatment plots; wind = 4 mph out of the west, temperature = 55-61°F, relative humidity = 80-91%.

**Application B:** July 5, 2012 at 6:15-7:30 am; lentils near the end of bloom; anthracnose at moderate levels in the non-treated checks; wind = 3-5 mph out of the north to northwest, temperature = 53-60°F, relative humidity = 79-90%.

<sup>u</sup> 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 including values below 1; LN(x) for data sets in which all values equal or exceed 1.0]. For ease of interpretation, treatment means are reported as disease severity.

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## SEED QUALITY:

Treatment (Fungicide application timing) <sup>y</sup>	SEED QUALITY							
	Viable seeds <sup>u</sup>	Split & broken <sup>t</sup>	Diseased <sup>s</sup>	Stained <sup>f</sup>	Discolored (Total) <sup>q</sup>	Wrinkled <sup>p</sup>	Grade - US <sup>n</sup>	Grade - Canada <sup>m</sup>
	percent	percent	percent	percent	percent	percent	1 to 4	1 to 5
1 Non-treated check (water)	88 ab *	2.8 a*	9.4 a*	14.3 a*	23.6 a*	20.8 ab*	4	5
2 Omega 500F 13.6 fl oz/ac (A,B) <sup>y</sup>	93 a	3.0 a	6.6 a	10.3 a	16.9 a	14.2 ab	4	5
3 Omega 500F 16 fl oz/ac (A,B)	95 a	2.2 a	6.5 a	9.5 a	16.0 a	15.1 ab	4	4
4 Omega 500F 16 fl oz/ac (A) / Headline 250SC 6 fl oz/ac (B)	93 ab	1.8 a	5.6 a	7.9 a	13.4 a	18.3 ab	4	4
5 Bravo WS 1.5 pt/ac (A) / Headline 250SC 6 fl oz/ac (B)	92 ab	2.5 a	5.4 a	10.2 a	15.6 a	20.3 ab	4	4
6 Headline 250SC 6 fl oz/ac (A,B)	95 a	2.0 a	4.1 a	9.7 a	13.8 a	14.2 ab	4	4
7 Xemium 2.23 fl oz/ac (A,B)	91 ab	2.4 a	8.4 a	12.9 a	21.3 a	22.7 b	4	5
8 Priaxor 500SC 4 fl oz/ac (A,B)	91 ab	1.6 a	6.5 a	10.1 a	16.6 a	14.8 ab	4	4
9 Priaxor 500SC 6 fl oz/ac (A,B)	93 a	1.7 a	4.1 a	10.2 a	14.4 a	13.1 a	4	4
10 Priaxor 500SC 4 fl oz/ac (A) / Proline 480SC 5.7 fl oz/ac + NIS 0.125% v/v (B)	94 a	2.6 a	5.8 a	8.1 a	13.9 a	15.8 ab	4	4
11 Proline 480SC 5 fl oz/ac + NIS 0.125% v/v (A,B)	89 ab	3.4 a	7.8 a	11.1 a	18.9 a	17.9 ab	4	5
12 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	92 ab	2.3 a	7.2 a	11.8 a	19.0 a	19.3 ab	4	4
13 Endura 70WG 6 oz/ac (A,B)	85 b	3.0 a	8.2 a	12.5 a	20.6 a	19.1 ab	4	5
14 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	90 ab	2.4 a	8.0 a	12.3 a	20.3 a	22.6 b	4	5
15 Inspire 250EC 6.4 fl oz/ac + Bravo WeatherStik 22.3 fl oz/ac (A,B) <sup>k</sup>	92 ab	2.2 a	9.2 a	10.4 a	19.6 a	16.0 ab	4	5
16 Quadris Top 8 fl oz/ac + NIS 0.125% v/v (A,B)	94 a	2.3 a	5.3 a	9.6 a	14.9 a	14.5 ab	4	4
17 Quadris 250SC 6.2 fl oz/ac (A,B)	92 ab	2.3 a	5.5 a	8.6 a	14.0 a	18.5 ab	4	4
18 Approach 2.08SC 12 fl oz/ac + NIS 0.125% v/v (A,B)	93 ab	2.8 a	6.2 a	10.8 a	17.0 a	19.7 ab	4	4
	F:	2.91	0.81	1.87	1.56	1.83	2.70	
	P > F:	0.0039	0.6723	0.0559	0.1297	0.0629	0.0060	
	CV:	3.1	44.5	35.0	25.6	26.0	20.6	

### <sup>y</sup> Fungicide application timings A and B:

**Application A:** June 22, 2012 at 6:30-7:30 am; 90% of plants with an open blossom; anthracnose symptoms present at low levels in the inoculated buffer plots but not the non-inoculated treatment plots; wind = 4 mph out of the west, temperature = 55-61°F, relative humidity = 80-91%.

**Application B:** July 5, 2012 at 6:15-7:30 am; lentils near the end of bloom; anthracnose at moderate levels in the non-treated checks; wind = 3-5 mph out of the north to northwest, temperature = 53-60°F, relative humidity = 79-90%.

<sup>u</sup> **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.

<sup>t</sup> **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).

<sup>s</sup> **Diseased:** Lentils with large dark colored lesions or obvious fungal growth on seed coat.

<sup>f</sup> **Stained:** Lentils with mottling, small dark-colored spots, or water spots (distinct light brown discoloration) on seed coat.

<sup>q</sup> **Discolored (total):** The combined total of diseased and stained seeds.

<sup>p</sup> **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.

<sup>n</sup> **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.

<sup>m</sup> **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).

<sup>k</sup> **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** [ $\text{LN}(x + 1)$ ] for data sets including values below 1;  $\text{LN}(x)$  for data sets in which all values equal or exceed 1.0]. **For ease of interpretation, treatment means are reported as disease severity.**

**The fungicides APPROACH, INSPIRE / BRAVO TOP, OMEGA, QUADRI TOP, 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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### METHODS – Agronomics and statistical analysis:

- **Location of trial:** NDSU Carrington Research Extension Center, Carrington, ND.
- **GPS coordinates of research trial location:** 47.4714,-99.1374
- **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:** April 25, 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.
- **Sclerotinia control:** To reduce Sclerotinia disease pressure in this trial, Contans (a commercial formulation of the Sclerotinia mycoparasite *Coniothyrium minitans*) was applied to the soil prior to seeding the trial. On April 18, 6 lbs/ac of Contans were applied in 17 gallons of water/ac and incorporated by harrowing to 1.0-1.5 inches within 30 min. of application. On April 25, 6 lbs/ac of Contans was applied in 28 gallons of water/ac and incorporated by harrowing to 1.0-1.5 inches within 1 hour of application.
- **Fungicide application A:** June 22, 2012 at 6:30-7:30 am; 90% of plants with an open blossom; anthracnose symptoms present at low levels in the inoculated buffer plots but not the non-inoculated treatment plots. Wind = 4 mph out of the west, temperature = 55-61°F, relative humidity = 80-91%.
- **Fungicide application B:** July 5, 2012 at 6:15-7:30 am; lentils near the end of bloom; anthracnose at moderate levels in the non-treated checks. Wind = 3-5 mph out of the north to northwest, temperature = 53-60°F, relative humidity = 79-90%.
- **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.
- **Anthracoze inoculation details:** To promote disease, anthracnose-infected lentil residues from the 2011 growing season were spread in the center of the buffer and guard plots on June 15 (just prior to bloom initiation). No residues were placed in the treatment plots. The residues were collected from a lentil variety trial that had a severe outbreak of anthracnose but no other foliar diseases above trace levels.
- **Disease assessments:** Anthracnose was the first foliar disease to develop above trace levels in this trial; approximately 2 weeks after the first appearance of anthracnose symptoms, Sclerotinia stem rot began to develop. Sclerotinia stem rot only developed in treatment plots where anthracnose was controlled with fungicides and the canopy was dense. No other diseases were present above trace levels. 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 20, 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 20.
- **Irrigation:** To facilitate disease establishment, overhead irrigation was applied with a center pivot shortly before and 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  $[\ln(x+1)]$  for data sets including values below 1.0;  $\ln(x)$  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 used in this trial, 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 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.

### 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.
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