

Field evaluation of fungicides for management of anthracnose on lentils

Hofflund / Nesson Valley, ND – 25 miles east of Williston (2012)

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KEY FINDINGS:

- Under moderate anthracnose pressure, the fungicides **Bravo Top** (difenoconazole + chlorothalonil), **Headline** (pyraclostrobin), **Priaxor** (pyraclostrobin + fluxapyroxad), **Quadris** (azoxystrobin), **Quadris Top** (azoxystrobin + chlorothalonil), and **Omega** (fluazinam) performed well.
- When anthracnose develops late in crop development, the impact of the disease on yield is limited. Anthracnose did not begin developing in this trial until the end of bloom, and it did not reach moderate to high levels in the non-treated control until late pod-fill.
- Under moderate anthracnose pressure, sequential applications of **Endura** (boscalid), **Proline** (prothioconazole), and **Quash** (metconazole) provided poor control of anthracnose.
- Use of the most effective foliar fungicides resulted in modest improvements in seed quality.

DETAILED RESULTS:

Disease control, yield, test weight and kernel weight

	Treatment (fungicide application timing) ^x	Anthracnose severity ^{z†}		Yield	Test weight	Seeds per pound
		July 25 ^y	Aug. 12 ^y			
		percent	percent	lbs/ac	lbs/bu	seeds
<p>The fungicides APPROACH, BRAVO TOP, OMEGA, QUADRIS TOP, and QUASH are currently not registered for use on lentils and should not be used.</p> <p>Future registration of some of these fungicides is anticipated, and results for these products are provided for reference only.</p>	1 Non-treated check	4 c *	24 c *	1566 a *	58.3 bc *	9087 bc *
	2 Omega 500F 13.6 fl oz/ac (A,B)	0 a	1 ab	1763 a	58.9 abc	8789 ab
	3 Omega 500F 16 fl oz/ac (A,B)	0 a	0 a	1671 a	58.4 abc	8797 ab
	4 Omega 500F 16 fl oz/ac (A) / Headline 250SC 6 fl oz/ac (B)	0 a	0 a	1822 a	59.1 ab	8755 ab
	5 Headline 250SC 6 fl oz/ac (A,B)	0 a	0 a	1918 a	59.2 a	8775 ab
	6 Priaxor 500SC 4 fl oz/ac (A,B)	0 a	0 a	1786 a	59.0 abc	8718 ab
	7 Priaxor 500SC 6 fl oz/ac (A,B)	0 a	0 a	1999 a	59.1 ab	8550 a
	8 Priaxor 500SC 4 fl oz/ac (A) / Proline 480SC 5.7 fl oz/ac + NIS 0.125% v/v (B)	0 a	0 a	1879 a	58.7 abc	8705 ab
	9 Proline 480SC 5 fl oz/ac + NIS 0.125% v/v (A,B)	2 ab	6 ab	1599 a	58.8 abc	8943 ab
	10 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	7 c	36 c	1596 a	58.2 c	9433 c
	11 Endura 70WG 6 oz/ac (A,B)	6 c	46 c	1717 a	58.7 abc	8985 abc
	12 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	4 bc	26 c	1849 a	58.7 abc	8944 ab
	13 Bravo Top 550SC 2 pt/ac (A,B)	0 a	2 ab	1801 a	58.8 abc	8756 ab
	14 Quadris Top 8 fl oz/ac + NIS 0.125% v/v (A,B)	0 a	1 ab	1847 a	59.0 abc	8902 ab
	15 Quadris 250SC 6.2 fl oz/ac (A,B)	0 a	4 ab	1690 a	58.6 abc	8710 ab
	16 Approach 2.08SC 12 fl oz/ac + NIS 0.125% v/v (A,B)	1 a	12 bc	1786 a	58.6 abc	8945 ab
		F: 19.93	17.94	0.86	3.12	5.20
		P > F: < 0.0001	< 0.0001	0.6139	0.0033	< 0.0001
		CV: 65.9	57.6	14.9	0.6	2.0

^z **Anthracnose:** Percent of the canopy with anthracnose symptoms and/or exhibiting plant mortality caused by anthracnose. No other foliar diseases were present above trace levels in this trial.

^y Lentils were at mid pod-fill on July 25 and late pod-fill on Aug. 12.

^x **Fungicide application timings A and B:**

Application A: June 28, 2012 at 10:00-11:00 am; less than 10% of plants with an open blossom, 18-nodes, 12-inch height; no anthracnose symptoms present; wind = 10-11 mph, temperature = 71-73°F, relative humidity = 43-48%.

Application B: July 12, 2012 at 11:00 am to 12:00 pm; average plant height was 12 to 14 inches; no anthracnose symptoms present; wind = 9-10 mph, temperature = 80-84°F, relative humidity = 56-66%.

* 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 the (untransformed) percent disease severity.

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SEED QUALITY:

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

Treatment (fungicide application timing) ^x	SEED QUALITY						
	Split & broken ^v percent	Diseased ^{u,‡} percent	Stained ^t percent	Discolored (Total) ^s percent	Wrinkled ^r percent	Grade - US ^q 1 to 4	Grade - Canada ^p 1 to 5
1 Non-treated check	1.4 a*	1.2 a*	8.5 a*	9.7 a*	5.0 a*	3	4
2 Omega 500F 13.6 fl oz/ac (A,B)	1.4 a	1.4 a	7.5 a	8.8 a	3.0 a	3	3
3 Omega 500F 16 fl oz/ac (A,B)	0.9 a	1.7 a	10.2 a	11.9 a	4.1 a	3	4
4 Omega 500F 16 fl oz/ac (A) / Headline 250SC 6 fl oz/ac (B)	0.8 a	1.9 a	8.1 a	10.0 a	3.3 a	3	4
5 Headline 250SC 6 fl oz/ac (A,B)	0.7 a	1.3 a	7.0 a	8.3 a	4.7 a	3	4
6 Priaxor 500SC 4 fl oz/ac (A,B)	1.4 a	0.5 a	7.7 a	8.1 a	5.0 a	2	3
7 Priaxor 500SC 6 fl oz/ac (A,B)	2.4 a	0.3 a	6.9 a	7.3 a	6.5 a	3	4
8 Priaxor 500SC 4 fl oz/ac (A) / Proline 480SC 5.7 fl oz/ac + NIS 0.125% v/v (B)	1.1 a	0.5 a	6.9 a	7.4 a	6.4 a	3	4
9 Proline 480SC 5 fl oz/ac + NIS 0.125% v/v (A,B)	1.6 a	0.7 a	7.8 a	8.4 a	6.3 a	2	4
10 Vertisan 1.67EC 20 fl oz/ac + NIS 0.125% v/v (A,B)	1.9 a	1.1 a	8.8 a	9.9 a	6.6 a	3	4
11 Endura 70WG 6 oz/ac (A,B)	1.3 a	0.6 a	9.2 a	9.8 a	6.7 a	3	4
12 Quash 50WDG 3 oz/ac + NIS 0.125% v/v (A,B)	1.4 a	0.6 a	7.8 a	8.5 a	6.3 a	3	4
13 Bravo Top 550SC 2 pt/ac (A,B)	0.9 a	1.0 a	6.3 a	7.2 a	5.2 a	3	3
14 Quadris Top 8 fl oz/ac + NIS 0.125% v/v (A,B)	1.1 a	1.3 a	9.0 a	10.3 a	5.0 a	3	4
15 Quadris 250SC 6.2 fl oz/ac (A,B)	1.6 a	0.9 a	8.1 a	8.9 a	6.2 a	3	4
16 Approach 2.08SC 12 fl oz/ac + NIS 0.125% v/v (A,B)	1.2 a	1.3 a	12.0 a	13.3 a	7.4 a	3	4
	F: 1.52	1.51	0.75	0.88	1.40		
	P > F: 0.1576	0.1582	0.7181	0.5934	0.2067		
	CV: 54.0	56.4	39.6	37.8	39.4		

^x Fungicide application timings A and B:

Application A: June 28, 2012 at 10:00-11:00 am; less than 10% of plants with an open blossom, 18-nodes, 12-inch height; no anthracnose symptoms present; wind = 10-11 mph, temperature = 71-73°F, relative humidity = 43-48%.

Application B: July 12, 2012 at 11:00 am to 12:00 pm; average plant height was 12 to 14 inches; no anthracnose symptoms present; wind = 9-10 mph, temperature = 80-84°F, relative humidity = 56-66%.

^w **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.

^v **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).

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

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

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

^r **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.

^q **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.

^p **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).

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

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METHODS – AGRONOMICS and STATISTICAL ANALYSIS:

- **Location of trial:** NDSU Williston Research Extension Center, Nesson Valley Irrigation Research Site
- **GPS coordinates of research trial location:** 48.1667,-103.1039
- **Soil type:** Lihen - fine sandy loam
- **Variety:** CDC 'Richlea' (a medium-green lentil)
- **Soil preparation:** fall - disked once, ripped twice, and mulched once; spring - harrowed once with a noble spring tooth harrow
- **Seeding equipment:** double-disc seeder (plot cone seeder)
- **Experimental design:** randomized complete block **Replicates:** 4
- **Seeded plot size:** 5 feet wide (center-to-center) x 18 feet long **Harvested plot size:** 5 feet wide (center-to-center) x approx. 14 feet long
- **Row spacing:** 7 inches **Rows per plot:** 6
- **Non-treated buffer plots were established between treatment plots.**
- **Previous crop:** durum wheat **Planting date:** May 2, 2012
- **Seeding rate:** 18 pure live seeds per square foot; average stand count across plots was 12.5 plants per square foot on May 25.
- **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 at 6 lbs/ac prior to seeding the trial.
- **Fungicide application A:** June 28, 2012 at 10:00-11:00 am; less than 10% of plants with an open blossom, 18-nodes, 12-inch height; no anthracnose symptoms present; wind = 10-11 mph, temperature = 71-73°F, relative humidity = 43-48%.
- **Fungicide application B:** July 12, 2012 at 11:00 am to 12:00 p; average plant height was 12 to 14 inches; no anthracnose symptoms present; wind = 9-10 mph, temperature = 80-84°F, relative humidity = 56-66%.
- **Fungicide application details:** Fungicides were applied with a 56-in hand boom with four equally spaced Spraying Systems TeeJet 8002VS flat-fan nozzles. Applications were made with 20 gal/ac water and 40 psi pressure.
- **Inoculation details:** To promote disease, anthracnose-infected lentil stems collected in Carrington, ND were placed in the 18-inch alley between plots on July 7. Two to four plants were placed between each plot.
- **Irrigation:** To facilitate disease establishment, overhead irrigation was applied with an overhead linear irrigation system.
- **Disease assessments:** Anthracnose was the only foliar disease to develop above trace levels in this trial. Anthracnose severity was assessed on July 25 and Aug. 12 as the percent of the plot showing symptoms of the disease.
- **Harvest date:** September 4, 2012. The lentils were desiccated on August 21, 2012 with 2 pt/ac Gramoxone (paraquat 200 g/L) + NIS (2.5 oz/ac) in 15 gallons of water/ac.
- **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] 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, the Tukey 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 as tested at the NDSU Williston Research Extension Center's Nesson Valley Irrigation Research Site 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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UNDAMAGED

WRINKLED

STAINED

DISEASED

METHODS – SEED QUALITY ASSESSMENTS

Seed quality assessments:

- **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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