

Field evaluation of fungicides for management of anthracnose on lentils

Carrington, ND (2013)

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KEY FINDINGS:

- Under a mixture of anthracnose and Sclerotinia disease pressure, the registered fungicides **Headline** (6 fl oz/ac) and **Priaxor** (4 or 6 fl oz/ac) and the experimental fungicides **Bravo Top** (2 pt/ac) and **Omega** (0.85 pt/ac) performed well.
- The efficacy of **Priaxor** was derived exclusively 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.
- Omega** exhibited a rate response, with anthracnose control increasing as the application rate increased. Under the high anthracnose disease pressure observed in this trial, 0.85 pt/ac of Omega was necessary for satisfactory anthracnose control.
- Approach** (12 fl oz/ac), **Endura** (6 oz/ac), **Inspire** (4 fl oz/ac), **Proline** (5 fl oz/ac), **ProPulse** (8 fl oz/ac), **Quadris** (6.2 fl oz/ac), and **Xemium** (3.34 fl oz/ac) provided poor control of anthracnose in this field trial.

Active ingredients: Approach contains 250 g picoxystrobin per liter, Bravo Weather Stik contains 720 g chlorothalonil per liter, Bravo Top contains 50 g difenoconazole + 500 g chlorothalonil per liter, Endura contains 700 g boscalid per kilogram, Headline contains 250 g pyraclostrobin per liter, Inspire contains 250 g difenoconazole per liter, Omega contains 500 g fluazinam per liter, Priaxor contains 333 g pyraclostrobin + 167 g fluxapyroxad per liter, Proline contains 480 g prothioconazole per liter, ProPulse contains 200 g prothioconazole + 200 g fluopyram per liter, Quadris contains 250 g azoxystrobin per liter, Xemium contains 300 g fluxapyroxad per liter.

SUMMARY OF KEY RESULTS:

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

Description (application timing) ^z	Anthracnose severity						
	Canopy necrosis: ^{x†} August 1 ^v percent	Stem lesions: ^w August 1 ^v 0 to 5	Canopy necrosis: ^{x†} Aug. 14 ^w percent	Sclerotinia severity: Aug. 14 ^w % of canopy	Yield: lbs/ac	Test weight: lbs/bu	Seeds per pound: [‡] seeds/lb
1 Non-treated check (water; A,B)	4 d *	4.0 de *	64 h*	0 a*	1140 f *	53.1 a *	13168 c *
2 Omega 500F 0.5 pt/ac (A,B)	0 a	2.0 a-e	36 e-h	0 a	1667 c-f	53.3 a	11451 abc
3 Inspire 250EC 4 fl oz/ac (A,B)	4 d	4.3 e	68 h	0 a	1080 f	52.0 a	12474 bc
4 Omega 500F 0.5 pt/ac + Inspire 250EC 4 fl oz/ac (A,B)	1 ab	1.8 a-e	39 e-h	0 a	1598 def	54.0 a	11423 abc
5 Omega 500F 0.675 pt/ac (A,B)	0 a	0.3 ab	15 d-g	0 a	1806 b-f	59.3 a	11436 abc
6 Omega 500F 0.675 pt/ac + Inspire 250EC 4 fl oz/ac (A,B)	0 ab	0.5 abc	10 c-f	0 a	2140 a-f	55.4 a	10930 abc
7 Omega 500F 0.85 pt/ac (A,B)	0 a	0.8 abc	9 cde	0 a	2504 a-e	56.0 a	11072 abc
8 Omega 500F 0.85 pt/ac (A) / Headline 250SC 6 fl oz/ac (B)	0 a	0.0 a	1 a	1 abc	3316 a	57.9 a	9226 a
9 Bravo WS 1.5 pt/ac (A) / Headline 250SC 6 fl oz/ac (B)	0 a	0.0 a	2 ab	1 abc	2802 a-d	56.7 a	10178 ab
10 Non-treated (water; A) / Headline 250SC 6 fl oz/ac (B)	1 ab	1.5 a-d	7 bcd	1 ab	2996 ab	62.7 a	10346 abc
11 Headline 250SC 6 fl oz/ac (A,B)	0 a	0.0 a	1 a	3 c	2901 abc	58.0 a	9814 ab
12 Priaxor 500SC 4 fl oz/ac (A,B)	0 a	0.0 a	1 a	2 abc	3117 a	57.9 a	10070 ab
13 Priaxor 500SC 6 fl oz/ac (A,B)	0 a	0.0 a	0 a	3 bc	3105 a	57.7 a	9959 ab
14 Xemium 300SC 3.34 fl oz/ac (A,B)	3 cd	4.3 e	69 h	0 a	1135 f	52.4 a	12045 bc
15 Bravo Top 550SC 2 pt/ac (A,B)	0 a	0.0 a	3 abc	1 ab	2890 abc	62.6 a	9743 ab
16 Endura 70WG 6 oz/ac (A,B)	2 bcd	3.8 de	59 h	0 a	1433 ef	53.9 a	11939 bc
17 Proline 480SC 5 fl oz/ac + NIS 0.125% v/v (A,B)	1 abc	2.8 b-e	38 fgh	0 a	1602 def	55.2 a	11691 abc
18 Quadris 250SC 6.2 fl oz/ac (A,B)	0 a	1.8 a-e	34 e-h	0 a	1702 c-f	54.5 a	11731 abc
19 ProPulse 400SC 8 fl oz/ac + NIS 0.125% v/v (A,B)	1 ab	2.4 a-e	43 gh	0 a	1673 c-f	50.9 a	11700 abc
20 Approach 250SC 12 fl oz/ac + NIS 0.125% v/v (A,B)	2 a-d	3.0 cde	43 gh	0 a	1517 ef	52.8 a	12377 bc
	F: 9.63	10.78	40.31	5.07	10.76	1.72	4.07
	F > P: < 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0729	< 0.0001
	CV: 91.5	58.6	18.7	156.3	22.1	9.0	1.0

^zFungicide application timing:

Application A: July 3, 2013 at 10:20 to 11:45 am, no foliar disease present above trace levels, 100% of plants with at least one open blossom and 5 days after first bloom, canopy not yet closed.

Application B: July 16, 2013 at 8:20 to 9:45 pm, foliar disease at moderate levels (approx. 5% incidence, with diseased plants exhibiting both stem and leaf lesions but no plant mortality), full bloom; Wind = 2.5 to 7 mph, temperature = 70 to 76° F, relative humidity = 66 to 75%.

^xAnthracnose disease severity - canopy necrosis: Percent of the canopy necrotic due to plants killed by anthracnose.

^wAnthracnose disease severity - stem lesion severity: The severity of anthracnose stem lesions was assessed on a 0 to 5 scale, in which 0 = anthracnose lesions on stems and leaves at zero to trace levels, lower canopy green; 1 = an average of one to three anthracnose stem lesions per plant, lower canopy green; 2 = an average of four to five anthracnose stem lesions per plant, lower canopy green; 3 = an average of five or more anthracnose stem lesions per plant and the bottom 1 to 25% of the lentil canopy necrotic; 4 = an average of ten or more anthracnose stem lesions per plant and the bottom 25 to 50% of the lentil canopy necrotic; and 5 = an average of ten or more anthracnose stem lesions per plant and more than 50% of the internal lentil canopy necrotic.

* 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]. For ease of interpretation, treatment means are reported as disease severity.

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SUMMARY OF KEY RESULTS – SEED QUALITY:

Seed Quality

Description (application timing) ^z	Split & broken ^t	Discolored (severe) ^{s†}	Stained ^q	Discolored (total) ^p	Wrinkled (severe) ⁿ	Protein
	percent	percent	percent	percent	percent	0% moisture percent
1 Non-treated check (water; A,B)	6 a *	15 a-d*	11 a *	26 abc*	8 a *	24.3
2 Omega 500F 0.5 pt/ac (A,B)	4 a	16 a-d	11 a	27 abc	9 a	24.7
3 Inspire 250EC 4 fl oz/ac (A,B)	5 a	29 d	13 a	41 c	7 a	24.2
4 Omega 500F 0.5 pt/ac + Inspire 250EC 4 fl oz/ac (A,B)	5 a	12 a-d	11 a	23 abc	7 a	24.0
5 Omega 500F 0.675 pt/ac (A,B)	3 a	11 a-d	11 a	21 abc	9 a	24.9
6 Omega 500F 0.675 pt/ac + Inspire 250EC 4 fl oz/ac (A,B)	5 a	11 a-d	7 a	18 ab	7 a	24.7
7 Omega 500F 0.85 pt/ac (A,B)	3 a	11 a-d	10 a	21 abc	8 a	25.5
8 Omega 500F 0.85 pt/ac (A) / Headline 250SC 6 fl oz/ac (B)	1 a	7 ab	5 a	12 a	5 a	25.5
9 Bravo WS 1.5 pt/ac (A) / Headline 250SC 6 fl oz/ac (B)	3 a	7 abc	6 a	13 a	6 a	25.4
10 Non-treated (water; A) / Headline 250SC 6 fl oz/ac (B)	5 a	8 a-d	8 a	15 ab	7 a	25.2
11 Headline 250SC 6 fl oz/ac (A,B)	4 a	8 abc	6 a	14 a	6 a	26.4
12 Priaxor 500SC 4 fl oz/ac (A,B)	2 a	7 abc	5 a	12 a	7 a	26.2
13 Priaxor 500SC 6 fl oz/ac (A,B)	4 a	8 a-d	8 a	16 ab	7 a	26.5
14 Xemium 300SC 3.34 fl oz/ac (A,B)	4 a	12 a-d	10 a	22 abc	6 a	24.6
15 Bravo Top 550SC 2 pt/ac (A,B)	4 a	4 a	5 a	9 a	5 a	24.5
16 Endura 70WG 6 oz/ac (A,B)	5 a	13 a-d	11 a	24 abc	8 a	24.4
17 Proline 480SC 5 fl oz/ac + NIS 0.125% v/v (A,B)	5 a	12 a-d	10 a	23 abc	12 a	24.6
18 Quadris 250SC 6.2 fl oz/ac (A,B)	4 a	11 a-d	9 a	21 abc	9 a	24.6
19 ProPulse 400SC 8 fl oz/ac + NIS 0.125% v/v (A,B)	5 a	25 cd	11 a	36 bc	9 a	24.9
20 Approach 250SC 12 fl oz/ac + NIS 0.125% v/v (A,B)	4 a	21 bcd	10 a	31 abc	11 a	25.7
	F:	1.43	3.65	2.08	3.99	1.87
	F > P:	0.1684	0.0003	0.0258	0.0001	0.0482
	CV:	47.9	19.9	36.7	38.8	32.7

Fungicide application timing:

Application A: July 3, 2013 at 10:20 to 11:45 am, no foliar disease present above trace levels, 100% of plants with at least one open blossom and 5 days after first bloom, canopy not yet closed.

Application B: July 16, 2013 at 8:20 to 9:45 pm, foliar disease at moderate levels (approx. 5% incidence, with diseased plants exhibiting both stem and leaf lesions but no plant mortality), full bloom; 2.5 to 7 mph wind, 70 to 76°F, 66 to 75% relative humidity.

^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**Discolored (severe):** The percent (by weight) of lentils exhibiting large dark colored lesions or obvious fungal growth on the seed coat. Lesions were defined as large if they covered at least 5% of the seed surface.

^q**Stained:** The percent (by weight) of lentils exhibiting water spots or other distinct light brown discoloration of the seed coat.

^p**Discolored (total):** The percent (by weight) of lentils exhibiting staining, minor discoloration, and severe discoloration.

ⁿ**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.

* **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]. For ease of interpretation, treatment means are reported as disease severity.

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

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- **Location of trial:** NDSU Carrington Research Extension Center, Carrington, ND. **GPS coordinates:** 47.509, -99.132
- **Soil type:** Heimdal-Emrick loam **Previous crop:** barley
- **Tillage:** Disked once in October 2012; cultivated twice (once deep, once shallow) on May 8, 2013.
- **Rhizobium inoculant:** Cell-Tech granular nitrogen fixing inoculant for pea and lentil (*Rhizobium leguminosarum* biovar viceae, 100 million viable cells per gram; Novozymes BioAg, Saskatoon, SK Canada) was mixed with the seed and applied at a rate of 2 dry ounces per 1000 feet of row.
- **Maintenance herbicide applications:** Sonalan HFP (ethalfuralin; Dow AgroSciences) was applied at 2 pts/ac in 11 gallons of water/ac on May 8. It was manually incorporated twice on May 8, once with a deep cultivation and once with a shallow cultivation.
- **Variety:** 'CDC Richlea'
- **Seed treatment:** Seeds were treated with 1.6 fl oz/cwt Axxess (imidacloprid) insecticide + 0.4 fl oz/ac Stamina (pyraclostrobin) fungicide.
- **Experimental design:** randomized complete block **Replicates:** 4
- **Seeded plot size:** 5 ft (center-to-center) x 25 ft long **Harvested plot size:** 5 ft (center-to-center) x approx. 21 ft long
- **Untreated buffer plots were established between treatment plots.**
- **Row spacing:** 7 inches **Rows per plot:** 7
- **Planting date:** May 9, 2013 **Seeding rate:** 18 pure live seeds/square foot
- **Fungicide application A:** July 3, 2013 at 10:20 to 11:45 am, no foliar disease present above trace levels, 100% of plants with at least one open blossom and 5 days after first bloom, canopy not yet closed.
- **Fungicide application B:** July 16, 2013 at 8:20 to 9:45 pm, foliar disease at moderate levels (approx. 5% incidence, with diseased plants exhibiting both stem and leaf lesions but no plant mortality), full bloom; Wind = 2.5 to 7 mph, temperature = 70 to 76°F, relative humidity = 66 to 75%.
- **Fungicide application details:** Fungicides were applied with a 57-inch hand boom equipped with four equally spaced Spraying Systems TeeJet XR 8001VS flat-fan nozzles at a spray volume of 15 gal water/A operated at 35 psi.
- **Disease establishment:** On July 5 when the lentils were in full bloom, anthracnose-infested lentil residues from the 2012 growing season were spread in buffer and guard plots. During bloom, overhead irrigation was applied to this trial through microsprinklers established on a 20 ft x 20 ft grid.
- **Anthracnose disease assessment:** On August 1 and August 14, anthracnose severity was assessed as the percent of the canopy exhibiting anthracnose disease symptoms and anthracnose associated necrosis and lodging. On August 1, the severity of anthracnose stem lesions was also assessed on a 0 to 5 scale, in which 0 = anthracnose lesions on stems and leaves at zero to trace levels, lower canopy green; 1 = an average of one to three anthracnose stem lesions per plant, lower canopy green; 2 = an average of four to five anthracnose stem lesions per plant, lower canopy green; 3 = an average of five or more anthracnose stem lesions per plant and the bottom 1 to 25% of the lentil canopy necrotic; 4 = an average of ten or more anthracnose stem lesions per plant and the bottom 25 to 50% of the lentil canopy necrotic; and 5 = an average of ten or more anthracnose stem lesions per plant and more than 50% of the internal lentil canopy necrotic.
- **Harvest date:** September 12 **The lentils matured naturally and were neither desiccated nor swathed.**
- **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 the model assumption of homoskedasticity, a systematic natural-log transformation $LN(x+1)$ for data sets including values below 1.0, otherwise $LN(x)$ was applied to the August 1 and August 14 anthracnose severity data. All other data met model assumptions without transformation. 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 implemented in PROC GLM of SAS (version 9.3; SAS Institute, Cary, NC).
- **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.
- **Discolored lentils (severe):** 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 water spots or other distinct light brown discoloration of the seed coat. From each plot, 250 lentils were assessed.
- **Discolored lentils (total):** 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.

WE GRATEFULLY ACKNOWLEDGE:

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We also gratefully acknowledge **BASF** for donating the seed treatment products Axxess and Stamina used 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 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 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.