

Response to fungicide seed treatment in field peas grown in fields with elevated Aphanomyces root rot pressure.

A research update from an ongoing project funded by grants from the USDA Specialty Crop Block Grant Program administered by the ND Department of Agriculture and the Northern Pulse Growers Association. Follow-up research is being conducted in 2026 in Carrington and at three on-farm locations in ND.

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Interpreting results from these studies:

- These are studies with high Aphanomyces and low to moderate Fusarium root rot pressure
- The results are not applicable to fields that do not have Aphanomyces root rot pressure
- Different results will be obtained from fields with high Fusarium pressure and low Aphanomyces pressure or fields that do not have Aphanomyces root rot pressure

Major findings:

- **Fungicide seed treatments with efficacy against Pythium and Rhizoctonia** consistently provided yield gains in field peas grown in fields with elevated Aphanomyces root rot pressure when soils were cool and wet after planting. Differences among the commercial pre-mix fungicide seed treatment fungicides VibranceMaxx Pulses RTA, Obvius, and Rancona Summit were modest when field peas were planted in late April to mid-May. VibranceMaxxPulses RTA and Rancona Summit were more effective than Obvius when peas were planted into very warm soils in late May or early June.
- **The addition of Trebuset, a fungicide seed treatment product targeting Fusarium, to VibranceMaxx Pulses** provided the greatest gains when seeding into warm soils in mid-May to early June. The additional yield gain conferred by adding the Fusarium product to the fungicide seed treatment was not sufficient to offset the loss in yield potential associated with planting into warm soils in fields with elevated Aphanomyces root rot pressure.

The response to fungicide seed treatment observed in these studies was due to management of Pythium, Rhizoctonia and Fusarium root rots, not Aphanomyces root rot. Testing was conducted in fields with Aphanomyces root rot pressure as a part of a broader effort to develop rigorous recommendations for profitable field pea production under Aphanomyces root rot pressure. Early planting when soils are cool improves the management of Aphanomyces root rot, a disease which is favored by warm soil. Early planting also increases the risk of losses to Pythium and Rhizoctonia root rots, diseases which are generally most severe in field peas seeded to cool soils. Fungicide seed treatment is a highly effective management tool for Pythium and Rhizoctonia root rot.

Root rot pressure and the relative contribution of *Aphanomyces euteiches*, *Fusarium* spp. and *Rhizoctonia solani*, causal agent of Aphanomyces, Fusarium and Rhizoctonia root rots to observed root disease in the field pea root rot management studies conducted in 2024 (Carrington) and 2025 (Carrington and on-farm locations).

	Root rot % of epicotyl and tap root diseased	Diagnostic test results DNA copies (diseased tissue)	Root rot disease pressure DNA copies (healthy & diseased tissue)
MAKOTI, ND (2025) ON-FARM LOCATION			
<i>Aphanomyces euteiches</i>	15%	3,992,473	590,741
<i>Fusarium</i> spp.		39,233	5,805
<i>Rhizoctonia solani</i>		25,819	3,820
CARRINGTON, ND (2025) FIELD Q9B			
<i>Aphanomyces euteiches</i>	44%	15,787,767	6,974,514
<i>Fusarium</i> spp.		53,692	23,720
<i>Rhizoctonia solani</i>		173,606	76,693
CARRINGTON, ND (2025) FIELD 17 EAST			
<i>Aphanomyces euteiches</i>	74%	13,717,310	10,211,750
<i>Fusarium</i> spp.		40,145	29,885
<i>Rhizoctonia solani</i>		40,637	30,252
CARRINGTON, ND (2024) FIELD 17 WEST			
<i>Aphanomyces euteiches</i>	64%	17,406,448	11,057,446
<i>Fusarium</i> spp.		92,016	58,453
<i>Rhizoctonia solani</i>		not tested	not tested
CARRINGTON, ND (2024) FIELD 18 SOUTH			
<i>Aphanomyces euteiches</i>	43%	27,176,166	11,623,448
<i>Fusarium</i> spp.		165,124	70,625
<i>Rhizoctonia solani</i>		not tested	not tested
WEBSTER, ND (2025) ON-FARM LOCATION			
<i>Aphanomyces euteiches</i>	99%	24,386,018	24,229,012
<i>Fusarium</i> spp.		99,535	98,894
<i>Rhizoctonia solani</i>		214,981	213,597

Diagnostic testing was conducted on diseased epicotyl tissue; shown are the combined diagnostic testing results conducted across 4 experimental replicates and 6 field pea varieties (Carrington field 18, 2024; Carrington field 17, 2024; Makoti, 2025; Webster, 2025), 17 field pea varieties (Carrington field Q9B, 2025), and 13 field pea varieties (Carrington field 17, 2025).

- Shown are the combined results obtained from testing conducted in the first two planting dates of the corresponding planting date studies. **Diagnostic testing was on diseased epicotyl tissue collected when peas were at early to mid-vegetative growth**, an appropriate growth stage to detect differences in Aphanomyces and Fusarium root rot.
- In 2024, diagnostic testing was conducted for *Aphanomyces euteiches*, *Fusarium avenaceum*, and *F. oxysporum*. In 2025, diagnostic testing was conducted for *A. euteiches*, *Rhizoctonia solani*, *Pythium* spp., *F. avenaceum*, *F. acuminatum*, *F. redolens*, *F. solani*, and *F. oxysporum*.
- Diagnostic testing results are not shown for *Pythium* because diseased field pea root and epicotyl tissue was not collected at an appropriate growth stage to detect *Pythium* spp., which primarily causes seed decay and early seedling mortality.

Impact of fungicide seed treatment on field pea agronomic performance in fields with elevated *Aphanomyces* root rot pressure; Webster, ND (2025)

large-plot study: each seed treatment was tested in 5 x 150 ft plots (in each of 4 replicates) in each field pea variety

Response to fungicide seed treatment: **Field pea yield (bu/ac)** **Webster, ND**
 PLANTING DATE #1: **May 4** **on-farm study (2025)**

Soils at this location were a heavy clay, and high soil moisture precluded earlier planting.

WEATHER CONDITIONS, first 7 days after planting:	Soil temperature: 58.0°F (average, day and night, first 7 days after planting) Rainfall: 0.01 inch. Daytime high temperature: 80.3°F average
WEATHER CONDITIONS, first 14 days after planting:	Soil temperature: 57.2°F (average, day and night, first 14 days after planting) Rainfall: 1.89 inch. Daytime high temperature: 73.5°F average

	FIELD PEA VARIETY:				Average across varieties	Yield gain conferred by seed treatment (bu/ac)
	Salamanca	Iconic	AAC Julius	PG Greenback		
Non-treated	21 b*	24 a*	29 a*	43 a*	29 c*	
Obvius 4.6 fl oz/cwt	26 a	26 a	30 a	46 a	32 a	+2.8 a
Obvius 4.6 fl oz + Stamina 1.5 fl oz/cwt	24 ab	23 a	28 a	44 a	30 abc	+1.2 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt	24 ab	24 a	29 a	44 a	30 bc	+0.6 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	26 a	24 a	30 a	46 a	30 abc	+1.1 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz + Trebuset 0.614 fl oz	22 ab	25 a	30 a	44 a	32 ab	+2.3 a
Rancona Summit 4 fl oz/cwt	25 ab	25 a	31 a	42 a	31 abc	+1.6 a
	<i>F, P>F:</i> 3.10, 0.0289 <i>CV:</i> 8.9	1.31, 0.3233 6.3	0.91, 0.5075 7.0	1.52, 0.2274 5.5	3.63, 0.0033 6.6	2.01, 0.1347 44.2

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

CIRCLE = yield gain conferred by one field pea variety

'Salamanca' = brown, 'Iconic' = yellow, 'AAC Julius' = blue, 'PG Greenback' = green

Response to fungicide seed treatment: **Field pea yield (bu/ac)** **Webster, ND**
 PLANTING DATE #2: **May 12-13** **on-farm study (2025)**

Cold, wet weather occurred after planting.

WEATHER CONDITIONS, first 7 days after planting:	Soil temperature: 51.2°F (average, day and night, first 7 days after planting) Rainfall: 1.91 inch. Daytime high temperature: 60.6°F average
WEATHER CONDITIONS, first 14 days after planting:	Soil temperature: 52.7°F (average, day and night, first 14 days after planting) Rainfall: 2.52 inch. Daytime high temperature: 62.1°F average

	FIELD PEA VARIETY:				Average across varieties	Yield gain conferred by seed treatment (bu/ac)
	Salamanca	Iconic	AAC Julius	PG Greenback		
Non-treated	21 a*	24 b*	32 a*	42 a*	30 b*	
Obvius 4.6 fl oz/cwt	24 a	29 a	35 a	43 a	33 a	+3.1 a
Obvius 4.6 fl oz + Stamina 1.5 fl oz/cwt	21 a	24 b	32 a	41 a	32 ab	+2.1 ab
Vibrance Maxx Pulses RTA 5 fl oz/cwt	23 a	25 ab	32 a	40 a	30 b	+0.0 c
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	22 a	27 ab	31 a	43 a	30 b	+0.5 bc
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz + Trebuset 0.614 fl oz	24 a	27 ab	33 a	43 a	31 ab	+1.0 bc
Rancona Summit 4 fl oz/cwt	23 a	26 ab	32 a	42 a	31 b	+0.9 bc
	<i>F, P>F:</i> 0.82, 0.5692 <i>CV:</i> 10.5	3.75, 0.0135 7.6	1.69, 0.1808 5.8	1.42, 0.2594 4.7	4.89, 0.0003 6.7	7.00, 0.0015 32.2

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

CIRCLE = yield gain conferred by one field pea variety

'Salamanca' = brown, 'Iconic' = yellow, 'AAC Julius' = blue, 'PG Greenback' = green

Impact of fungicide seed treatment on field pea agronomic performance in fields with elevated *Aphanomyces* root rot pressure; Makoti, ND (2025)

large-plot study: each seed treatment was tested in 5 x 150 ft plots (in each of 4 replicates) in each field pea variety

Response to fungicide seed treatment: **Field pea yield (bu/ac)**

Makoti, ND

PLANTING DATE #1: **April 25**

on-farm study (2025)

This date corresponded with the start of widespread planting in the area.

WEATHER CONDITIONS, first 7 days after planting: Soil temperature: 47.3°F (average, day and night, first 7 days after planting)
Rainfall: 0.05 inch. Daytime high temperature: 61.0°F average

WEATHER CONDITIONS, first 14 days after planting: Soil temperature: 51.2°F (average, day and night, first 14 days after planting)
Rainfall: 0.05 inch. Daytime high temperature: 51.2°F average

	FIELD PEA VARIETY:				Average across varieties	Yield gain conferred by seed treatment (bu/ac)
	Salamanca	Iconic	AAC Julius	PG Greenback		
Non-treated	28 b*	31 ab*	28 a*	35 a*	31 a*	
Obvius 4.6 fl oz/cwt	30 a	35 a	29 a	35 a	32 a	+1.5 a
Obvius 4.6 fl oz + Stamina 1.5 fl oz/cwt	31 ab	31 b	28 a	35 a	32 a	+1.0 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt	31 ab	31 b	29 a	34 a	31 a	+0.6 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	29 a	33 ab	30 a	34 a	31 a	+0.6 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz + Trebuset 0.614 fl oz	30 ab	33 ab	29 a	35 a	31 a	+0.9 a
Rancona Summit 4 fl oz/cwt	28 ab	32 ab	30 a	36 a	31 a	+0.8 a
	<i>F, P>F:</i> 1.52, 0.2273				0.75, 0.6143	0.38, 0.8577
	CV: 6.0				3.9	71.9

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

CIRCLE = yield gain conferred by one field pea variety

'Salamanca' = brown, 'Iconic' = yellow, 'AAC Julius' = blue, 'PG Greenback' = green

Response to fungicide seed treatment: **Field pea yield (bu/ac)**

Makoti, ND

PLANTING DATE #2: **May 13**

on-farm study (2025)

Cool, wet weather occurred after planting.

WEATHER CONDITIONS, first 7 days after planting: Soil temperature: 47.1°F (average, day and night, first 7 days after planting)
Rainfall: 6.26 inch. Daytime high temperature: 46.7°F average

WEATHER CONDITIONS, first 14 days after planting: Soil temperature: 49.2°F (average, day and night, first 14 days after planting)
Rainfall: 6.49 inch. Daytime high temperature: 55.4°F average

	FIELD PEA VARIETY:				Average across varieties	Yield gain conferred by seed treatment (bu/ac)
	Salamanca	Iconic	AAC Julius	PG Greenback		
Non-treated	32 a*	36 b*	34 a*	40 a*	35 a*	
Obvius 4.6 fl oz/cwt	33 a	39 a	34 a	42 a	37 a	+1.7 a
Obvius 4.6 fl oz + Stamina 1.5 fl oz/cwt	32 a	40 b	35 a	40 a	37 a	+1.7 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt	33 a	40 ab	33 a	42 a	37 a	+1.2 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	33 a	39 ab	37 a	42 a	37 a	+1.4 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz + Trebuset 0.614 fl oz	35 a	38 ab	35 a	41 a	38 a	+2.0 a
Rancona Summit 4 fl oz/cwt	33 a	41 ab	35 a	41 a	37 a	+1.7 a
	<i>F, P>F:</i> 1.59, 0.2074				1.44, 0.2554	0.27, 0.9243
	CV: 4.3				3.4	48.0

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

CIRCLE = yield gain conferred by one field pea variety

'Salamanca' = brown, 'Iconic' = yellow, 'AAC Julius' = blue, 'PG Greenback' = green

Impact of fungicide seed treatment on field pea agronomic performance in fields with elevated Aphanomyces root rot pressure; Carrington, ND (2025)

small-plot study: 5 x 30 ft plots, 6 replicates; shown is the combined analysis across two studies conducted in different fields

Response to fungicide seed treatment:
Field pea yield (bu/ac)

Carrington, ND
field Q9B & field 17 (2025)

Treatment	PLANT DATE #1: April 23-24			Yield gain (bu/ac) conferred by seed treatment
	AAC Julius	Iconic	Combined analysis	
Non-treated control	69 a	56 a	63 a	
Obvius 4.6 fl oz/cwt	67 a	59 a	63 a	+0.4 A
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	68 a	62 a	65 a	+2.3 A
Vibrance Maxx Pulses RTA 5 fl oz/cwt	67 a	61 a	64 a	+1.1 A
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	66 a	59 a	62 a	-0.3 A
Vibrance Maxx Pulses + Vayantis + Trebuset 0.614 fl oz/cwt	69 a	62 a	66 a	+3.0 A
Rancona Summit 4 fl oz/cwt	68 a	56 a	62 a	-0.6 A
F, P>F: 1.01, 0.4379 1.53, 0.2022 1.23, 0.3183			1.46, 0.2383	
CV: 4.9 8.3 4.8			34.3	
Treatment	PLANT DATE #2: May 5			Yield gain (bu/ac) conferred by seed treatment
	AAC Julius	Iconic	Combined analysis	
Non-treated control	70 a	59 a	65 a	
Obvius 4.6 fl oz/cwt	71 a	60 a	66 a	+0.9 A
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	71 a	64 a	68 a	+3.2 A
Vibrance Maxx Pulses RTA 5 fl oz/cwt	72 a	64 a	68 a	+3.4 A
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	72 a	66 a	69 a	+4.2 A
Vibrance Maxx Pulses + Vayantis + Trebuset 0.614 fl oz/cwt	71 a	62 a	66 a	+1.8 A
Rancona Summit 4 fl oz/cwt	70 a	64 a	67 a	+2.4 A
F, P>F: 0.2, 0.9684 2.28, 0.0621 1.52, 0.2056			1.00, 0.4387	
CV: 5.7 6.4 4.4			36.2	
Treatment	PLANT DATE #3: May 27			Yield gain (bu/ac) conferred by seed treatment
	AAC Julius	Iconic	Combined analysis	
Non-treated control	53 ab	40 c	47 b	
Obvius 4.6 fl oz/cwt	53 ab	40 c	46 b	-0.2 B
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	52 b	41 bc	46 b	-0.2 B
Vibrance Maxx Pulses RTA 5 fl oz/cwt	57 ab	49 a	53 a	+6.1 A
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	54 ab	47 abc	50 a	+3.8 AB
Vibrance Maxx Pulses + Vayantis + Trebuset 0.614 fl oz/cwt	56 ab	49 a	53 a	+6.1 A
Rancona Summit 4 fl oz/cwt	57 a	49 ab	53 a	+6.1 A
F, P>F: 2.42, 0.0498 6.26, 0.0002 10.38, <0.0001			10.52, <0.0001	
CV: 6.2 9.2 4.8			31.3	
Treatment	PLANT DATE #4: June 5			Yield gain (bu/ac) conferred by seed treatment
	AAC Julius	Iconic	Combined analysis	
Non-treated control	49 a	25 c	37 b	
Obvius 4.6 fl oz/cwt	48 a	26 c	37 b	+0.2 A
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	49 a	32 b	40 ab	+3.6 A
Vibrance Maxx Pulses RTA 5 fl oz/cwt	48 a	35 ab	41 ab	+4.5 A
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	50 a	33 ab	41 ab	+4.5 A
Vibrance Maxx Pulses + Vayantis + Trebuset 0.614 fl oz/cwt	53 a	39 a	46 a	+8.9 A
Rancona Summit 4 fl oz/cwt	52 a	34 ab	43 a	+6.0 A
F, P>F: 0.85, 0.5394 6.25, 0.0002 6.91, 0.0001			5.45, 0.0016	
CV: 10.0 9.2 7.2			21.6	

SCATTER PLOTS: bars = average response, circles = response observed in each field pea variety
yellow circles = 'Iconic' and blue circles = 'AAC Julius'

Within-column means followed by different letters are significantly different (P < 0.05)

Response to fungicide seed treatment in field peas seeded to fields with elevated Aphanomyces root rot pressure Fields 17 and 18, Carrington, ND (2024)
 small-plot study: each seed treatment was planted to 5 ft x 30 ft plots to each field pea variety in each replicate; 6 replicates

Carrington, ND (2024)		FIELD 17 grown: 2021		FIELD 18 grown: 2015		FIELD 17 grown: 2021		FIELD 18 grown: 2015											
Planting date #1: April 23-24	Planting date #2: May 10	Planting date #3: May 22	Planting date #4: June 12-13	Planting date #1: April 23	Planting date #2: May 12	Planting date #3: May 22	Planting date #4: June 12	Planting date #1: April 23	Planting date #2: May 12	Planting date #3: May 22	Planting date #4: June 12								
soil temperature = 45.2°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 60.3°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 56.4°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 67.6°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 45.8°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 58.6°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 55.3°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 57.0°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 45.8°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 58.6°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 55.3°F (ave. at 2" depth, first 7 days after planting)	soil temperature = 57.0°F (ave. at 2" depth, first 7 days after planting)								
Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt	Wilt								
80-97% pod-fill	75-90% pod-fill	85-100% pod-fill	40-85% pod-fill	85-100% pod-fill	70-100% pod-fill	85-100% pod-fill	78-100% pod-fill	85-100% pod-fill	70-100% pod-fill	85-100% pod-fill	78-100% pod-fill								
% of plants	% of plants	% of plants	% of plants	% of plants	% of plants	% of plants	% of plants	% of plants	% of plants	% of plants	% of plants								
Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield	Yield								
bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	bu/ac	bu/ac								
Non-treated seed	27 b*	60 b	58 d*	24 b	64 c*	18 bc	71 b*	9 c	27 b*	60 b	58 d*	24 b	64 c*	18 bc	71 b*	9 c			
Obvius, 4.6 fl oz/cwt	18 a	66 a	51 bc	30 a	61 bc	21 abc	72 ab	9 c	18 a	66 a	51 bc	30 a	61 bc	21 abc	72 ab	9 c			
Obvius, 4.6 fl oz/cwt + Relyna, 0.4 fl oz/cwt	20 a	66 a	54 cd	30 a	65 c	18 c	72 ab	8 c	20 a	66 a	54 cd	30 a	65 c	18 c	72 ab	8 c			
Vibrance Total, 5 fl oz/cwt	17 a	71 a	47 b	32 a	57 b	22 a	68 ab	10 b	17 a	71 a	47 b	32 a	57 b	22 a	68 ab	10 b			
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	17 a	67 a	42 a	34 a	50 a	24 a	61 a	12 a	17 a	67 a	42 a	34 a	50 a	24 a	61 a	12 a			
F, P>F: 12.32, <0.0001		6.43, <0.0001		24.54, <0.0001		11.30, <0.0001		17.17, <0.0001		5.59, 0.0004		8.65, <0.0001		13.9		24.3			
CV: 34.9		12.9		14.6		20.1		15.5		30.1		13.9		24.3					
Carrington, ND (2024)												FIELD 17		FIELD 18		FIELD 17		FIELD 18	
last time peas or lentils were grown: 2015												grown: 2021		grown: 2015		grown: 2021		grown: 2015	
Non-treated seed	13 b	48 b	28 d	28 b	35 c	26 c	91 b*	12 cd	13 b	48 b	28 d	28 b	35 c	26 c	91 b*	12 cd			
Obvius, 4.6 fl oz/cwt	9 ab	53 a	21 bc	31 ab	32 bc	29 b	89 b	14 c	9 ab	53 a	21 bc	31 ab	32 bc	29 b	89 b	14 c			
Obvius, 4.6 fl oz/cwt + Relyna, 0.4 fl oz/cwt	12 b	52 a	22 c	31 ab	35 c	28 bc	92 b	12 d	12 b	52 a	22 c	31 ab	35 c	28 bc	92 b	12 d			
Vibrance Total, 5 fl oz/cwt	8 ab	52 a	18 ab	30 ab	28 b	30 ab	85 a	16 b	8 ab	52 a	18 ab	30 ab	28 b	30 ab	85 a	16 b			
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	7 a	53 a	16 a	32 a	23 a	32 a	84 a	18 a	7 a	53 a	16 a	32 a	23 a	32 a	84 a	18 a			
F, P>F: 5.33, <0.0001		40.02, <0.0001		17.84, <0.0001		3.97, <0.0001		15.82, <0.0001		15.84, <0.0001		10.26, <0.0001		42.99, <0.0001					
CV: 26.4		8.9		30.3		13.5		8.5		10.6		7.1		14.2					

Figure 9. Yield response to fungicide seed treatment in field peas grown under Aphanomyces pressure; Carrington, ND (2024).

Webster, ND on-farm study (2025)

AVERAGE RESPONSE ACROSS FOUR FIELD PEA VARIETIES: Salamanca, Iconic, AAC Julius, PG Greenback
 large plot sizes: each seed treatment was tested in 5 x 150 ft plots (in each of 4 replicates) at seeding in each field pea variety

PLANTING DATE #1	WEATHER CONDITIONS, first 7 days after planting:		WEATHER CONDITIONS, first 14 days after planting:	
	Soil temperature: 58.0°F (average, day and night, first 7 days after planting) Rainfall: 0.01 inch. Daytime high temperature: 80.3°F average	Soil temperature: 57.2°F (average, day and night, first 14 days after planting) Rainfall: 1.89 inch. Daytime high temperature: 73.5°F average		

Non-treated control	Root rot		Active Rhizobium		Wilt		Vigor		Yield		Yield gain from seed treatment		Protein		Test weight	
	June 8: 7-8 nodes Incidence % of plants	Severity % sev index	June 8: 7-8 nodes Incidence % of plants	June 16-17: 90-100% pod-fill Incidence % of plants	July 16-17: 90-100% pod-fill Incidence % of plants	Soil temperature: 51.2°F (average, day and night, first 7 days after planting) Rainfall: 1.91 inch. Daytime high temperature: 60.6°F average	Soil temperature: 52.7°F (average, day and night, first 14 days after planting) Rainfall: 2.52 inch. Daytime high temperature: 62.1°F average	Yield 13.5% moisture bu/ac	Yield from seed treatment bu/ac	Protein %	Test weight lbs/bu					
Obvius 4.6 fl oz/cwt	100	99	15 a*	2.1 c††	65 a*	29 c*	21.5 a*	63.4 a*								
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	100	100	20 a	1.8 bc	66 a	32 a	2.8 a	21.4 a	63.7 a							
Vibrance Maxx Pulses RTA 5 fl oz/cwt	99	99	22 a	2.0 bc	66 a	30 abc	1.2 a	21.5 a	63.8 a							
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	100	100	17 a	1.3 b	66 a	30 bc	0.6 a	21.8 a	63.6 a							
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz + Saitro 0.614 fl oz	100	99	17 a	1.3 ab	65 a	30 abc	1.1 a	21.4 a	63.5 a							
Rancona Summit 4 fl oz/cwt	100	98	24 a	0.8 a	67 a	32 ab	2.3 a	21.6 a	63.6 a							
		F, P>F:	0.71, 0.6388	7.67, <0.0001	1.43, 0.2155	3.63, 0.0033	2.01, 0.1347	1.11, 0.3659	1.41, 0.2222							
		CV:	73.4	27.9	4.6	6.6	44.2	2.7	0.7							

PLANTING DATE #1	WEATHER CONDITIONS, first 7 days after planting:		WEATHER CONDITIONS, first 14 days after planting:	
	Soil temperature: 51.2°F (average, day and night, first 7 days after planting) Rainfall: 1.91 inch. Daytime high temperature: 60.6°F average	Soil temperature: 52.7°F (average, day and night, first 14 days after planting) Rainfall: 2.52 inch. Daytime high temperature: 62.1°F average		

Non-treated control	Root rot		Active Rhizobium		Wilt		Vigor		Yield		Yield gain from seed treatment		Protein		Test weight	
	June 25: 8-10 nodes Incidence % of plants	Severity % sev index	June 25: 8-10 nodes Incidence % of plants	July 23-24: 87-100% pod-fill Incidence % of plants	Soil temperature: 51.2°F (average, day and night, first 7 days after planting) Rainfall: 1.91 inch. Daytime high temperature: 60.6°F average	Soil temperature: 52.7°F (average, day and night, first 14 days after planting) Rainfall: 2.52 inch. Daytime high temperature: 62.1°F average	Yield 13.5% moisture bu/ac	Yield from seed treatment bu/ac	Protein %	Test weight lbs/bu						
Obvius 4.6 fl oz/cwt	100	98	37 a††	1.0 c††	70 a*	30 b*	21.9 a*	63.6 a*								
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	100	100	18 a	0.9 bc	72 a	33 a	3.1 a	22.1 a	63.7 a							
Vibrance Maxx Pulses RTA 5 fl oz/cwt	100	100	17 a	0.9 bc	72 a	32 ab	2.1 ab	22.3 a	63.9 a							
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	100	100	13 a	0.6 ab	71 a	30 b	0.0 c	21.9 a	63.8 a							
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz + Saitro 0.614 fl oz	100	98	26 a	0.7 abc	69 a	30 b	0.5 bc	22.2 a	63.7 a							
Rancona Summit 4 fl oz/cwt	100	100	22 a	0.4 a	71 a	31 ab	1.0 bc	22.1 a	63.8 a							
		F, P>F:	0.61, 0.7210	1.37, 0.2378	4.61, 0.0005	2.23, 0.0501	4.89, 0.0003	7.00, 0.0015	0.77, 0.5964	0.93, 0.4771						
		CV:	53.6	62.0	34.3	3.5	6.7	32.2	4.4	0.6						

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

† To meet model assumptions of normality and/or homoskedasticity, analysis of variance was conducted on data subjected to a systematic natural-log transformation. For ease of interpretation, treatments means are presented for the non-transformed data.

Carrington, ND (2025)

AVERAGE RESPONSE across two field pea varieties (Iconic and AAC Julius) tested across two fields
Small plot sizes: 5 x 30 ft plots; 6 replicates on each of 2 fields (fields '17' and 'Q9B', total 12 replicates)

PLANT DATE #1 April 23-24	WEATHER CONDITIONS, first 7 days									
	Soil temperature: 44.2°F (average, day and night, first 7 days after planting) after planting: Rainfall: 0.91 inch. Daytime high temperature: 58.0°F average									
Response to fungicide seed treatment	WEATHER CONDITIONS, first 14 days after planting									
	Soil temperature: 48.5°F (average, day and night, first 14 days after planting) days after planting: Rainfall: 0.91 inch. Daytime high temperature: 65.3°F average									
PLANT DATE	Root rot		Active Rhizobium		Wilt		Yield	Yield gain from seed treatment	Protein	Test weight
	Incidence	Severity	Incidence	% active nodules	Incidence	% of plants				
	% of plants	% sev index	% of plants	% of plants	% of plants	% of plants	bu/ac	bu/ac	%	lbs/bu
Non-treated control	81 a	51 a	84 a	47 a	0.9 b	63 a	0.4 a	22.8 a	23.1 a	63.0 a
Obvius 4.6 fl oz/cwt	80 a	49 a	87 a	51 a	0.7 ab	63 a	0.4 a	22.8 a	23.1 a	63.0 a
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	78 a	51 a	89 a	56 a	0.4 ab	65 a	2.3 a	22.9 a	23.1 a	62.9 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt	75 a	53 a	84 a	43 a	0.6 ab	64 a	1.1 a	23.1 a	23.1 a	63.0 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	78 a	50 a	86 a	52 a	0.5 ab	62 a	-0.3 a	23.1 a	23.1 a	63.0 a
Vibr M Pulse RTA 5 fl oz + Vayantis 0.1 fl oz + Salstro 0.614 fl oz	68 a	49 a	87 a	55 a	0.3 a	66 a	3.0 a	23.1 a	23.1 a	63.0 a
Rancona Summit 4 fl oz/cwt	76 a	54 a	88 a	51 a	0.5 ab	62 a	-0.6 a	22.9 a	22.9 a	62.9 a
	F:	1.71	0.26	0.32	1.51	3.07	1.23	1.46	0.89	0.35
	P>F:	0.1617	0.9515	0.9224	0.2176	0.0182	0.3181	0.2383	0.5116	0.9070
	CV:	9.5	15.7	8.6	16.2	53.1	4.8	34.3	1.6	0.3

PLANT DATE #2 May 5	WEATHER CONDITIONS, first 7 days									
	Soil temperature: 61.2°F (average, day and night, first 7 days after planting) after planting: Rainfall: 0 inch. Daytime high temperature: 81.6°F average									
Response to fungicide seed treatment	WEATHER CONDITIONS, first 14 days after planting									
	Soil temperature: 58.6°F (average, day and night, first 14 days after planting) days after planting: Rainfall: 1.31 inch. Daytime high temperature: 72.3°F average									
PLANT DATE	Root rot		Active Rhizobium		Wilt		Yield	Yield gain from seed treatment	Protein	Test weight
	Incidence	Severity	Incidence	% active nodules	Incidence	% of plants				
	% of plants	% sev index	% of plants	% of plants	% of plants	% of plants	bu/ac	bu/ac	%	lbs/bu
Non-treated control	96 c	64 a	59 a	28 a	1.1 b	65 a	0.9 a	22.9 a	22.6 a	62.8 a
Obvius 4.6 fl oz/cwt	95 bc	72 a	49 a	20 a	0.7 ab	66 a	0.9 a	22.9 a	22.6 a	62.8 a
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt	92 abc	60 a	57 a	26 a	0.5 ab	68 a	3.2 a	22.9 a	22.9 a	62.9 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt	85 a	53 a	62 a	30 a	0.4 a	68 a	3.4 a	23.1 a	23.1 a	62.7 a
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt	88 abc	57 a	64 a	34 a	0.4 a	69 a	4.2 a	23.0 a	23.0 a	62.9 a
Vibr M Pulse RTA 5 fl oz + Vayantis 0.1 fl oz + Salstro 0.614 fl oz	87 ab	66 a	55 a	29 a	0.6 ab	66 a	1.8 a	23.0 a	23.0 a	62.8 a
Rancona Summit 4 fl oz/cwt	90 abc	61 a	66 a	28 a	0.6 ab	67 a	2.4 a	22.8 a	22.8 a	62.8 a
	F:	4.25	1.91	1.55	1.41	2.65	1.52	1.00	1.31	0.8
	P>F:	0.0033	0.1113	0.1964	0.2449	0.0347	0.2056	0.4387	0.2829	0.5749
	CV:	5.1	17.5	19.2	30.8	64.4	4.4	36.2	1.7	0.4

Carrington, ND (2025)

AVERAGE RESPONSE across two field pea varieties (Iconic and AAC Julius) tested across two fields
Small plot sizes: 5 x 30 ft plots; 6 replicates on each of 2 fields (fields '17' and 'Q9B', total 12 replicates)

PLANT DATE #3 May 27	WEATHER CONDITIONS, first 7 days										
	Soil temperature: 64.2°F (average, day and night, first 7 days after planting) after planting: Rainfall: 0.08 inch. Daytime high temperature: 76.4°F average										
Response to fungicide seed treatment	WEATHER CONDITIONS, first 14 days after planting										
	Soil temperature: 62.6°F (average, day and night, first 14 days after planting) days after planting: Rainfall: 0.36 inch. Daytime high temperature: 73.9°F average										
PLANT DATE	Root rot		Active Rhizobium		Wilt		Yield	Yield gain from seed treatment	Protein	Test weight	
	Incidence	Severity	Incidence	% active nodules	Incidence	% of plants					13.5% moisture
	% of plants	% sev index	% of plants	% of plants	% of plants	% of plants	bu/ac	bu/ac	%	lbs/bu	
Non-treated control						24 b	47 b	24.3 a	63.1 a		
Obvius 4.6 fl oz/cwt						25 ab	46 b	-0.2 b	23.9 a	63.3 a	
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt						18 ab	46 b	-0.2 b	24.1 a	63.6 a	
Vibrance Maxx Pulses RTA 5 fl oz/cwt						15 a	53 a	6.1 a	24.0 a	63.2 a	
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt						14 a	50 a	3.8 ab	23.8 a	63.4 a	
Vibr M Pulse RTA 5 fl oz + Vayantis 0.1 fl oz + Salstro 0.614 fl oz						14 a	53 a	6.1 a	24.2 a	63.5 a	
Rancona Summit 4 fl oz/cwt						14 a	53 a	6.1 a	24.0 a	63.6 a	
						F:	8.34	10.38	10.52	1.57	1.29
						P>F:	< 0.0001	< 0.0001	< 0.0001	0.1917	0.2914
						CV:	22.9	4.8	31.3	1.4	0.6

PLANT DATE #4 June 5	WEATHER CONDITIONS, first 7 days										
	Soil temperature: 60.5°F (average, day and night, first 7 days after planting) after planting: Rainfall: 0.21 inch. Daytime high temperature: 70.7°F average										
Response to fungicide seed treatment	WEATHER CONDITIONS, first 14 days after planting										
	Soil temperature: 62.8°F (average, day and night, first 14 days after planting) days after planting: Rainfall: 0.88 inch. Daytime high temperature: 73.5°F average										
PLANT DATE	Root rot		Active Rhizobium		Wilt		Yield	Yield gain from seed treatment	Protein	Test weight	
	Incidence	Severity	Incidence	% active nodules	Incidence	% of plants					13.5% moisture
	% of plants	% sev index	% of plants	% of plants	% of plants	% of plants	bu/ac	bu/ac	%	lbs/bu	
Non-treated control						45 b	37 b	24.0 b	62.8 a		
Obvius 4.6 fl oz/cwt						46 b	37 b	0.2 a	24.2 ab	62.7 a	
Obvius 4.6 fl oz/cwt + Stamina 1.5 fl oz/cwt						35 a	40 ab	3.6 a	24.0 b	62.7 a	
Vibrance Maxx Pulses RTA 5 fl oz/cwt						30 a	41 ab	4.5 a	24.5 ab	62.9 a	
Vibrance Maxx Pulses RTA 5 fl oz/cwt + Vayantis 0.1 fl oz/cwt						34 a	41 ab	4.5 a	24.4 ab	62.9 a	
Vibr M Pulse RTA 5 fl oz + Vayantis 0.1 fl oz + Salstro 0.614 fl oz						28 a	46 a	8.9 a	24.5 a	62.9 a	
Rancona Summit 4 fl oz/cwt						33 a	43 a	6.0 a	24.4 ab	62.9 a	
						F:	14.07	6.91	5.45	2.95	1.47
						P>F:	< 0.0001	0.0001	0.0016	0.0221	0.2216
						CV:	12.5	7.2	21.6	1.3	0.3

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

Carrington, ND (2024) AVERAGE RESPONSE across six field pea varieties: AAC IronHorse, AAC Julius, AAC Profit, ND Dawn, Caphorn and LG Amigo. Small-plot study (5 x 30 ft at planting); 6 replicates.

PLANTING DATE #1

Plant population	Total root rot			Aphanomyces root rot	Fusarium root rot	Vascular Necrosis	Wilted plants	Yield	Test Weight	
	Incidence	Severity	Severity Index	Sev. index	Sev. index	% incidence				
3-4 nodes plants/ac	Assessed at early vegetative growth (Field 17, 5-6 nodes; Field 18, 4-5 nodes)						80-97% pod fill	13.5% moisture	lbs/bu	
FIELD 17: April 23-24; 45.2°F average soil temperature at seeding depth in the first 7 days after planting.										
Non-treated seed	272202	68	51	36	29	7	0.2	27 b*	60 b*	62.0
Obvius, 4.6 fl oz/cwt	280914	63	46	30	24	6	0.1	18 a	66 a	61.9
Obvius, 4.6 fl oz/cwt + Relenya, 0.4 fl oz/cwt	271234	60	49	30	24	6	0.2	20 a	66 a	61.8
Vibrance Total, 5 fl oz/cwt	284882	59	50	31	24	7	0.2	17 a	71 a	61.5
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	271137	61	48	32	26	6	0.2	17 a	67 a	61.7
	F, P>F: CV:						12.3, <0.0001	6.4, <0.0001		
							54.9	12.9		

FIELD 18: April 23; 45.8°F average soil temperature at seeding depth in the first 7 days after planting.

Non-treated seed	220472	10	44	5	5	1	0.8	13 b*†	48 b*	61.3
Obvius, 4.6 fl oz/cwt	247072	9	37	3	3	0	0.1	9 ab	53 a	61.5
Obvius, 4.6 fl oz/cwt + Relenya, 0.4 fl oz/cwt	229416	9	44	4	3	1	0.9	12 b	52 a	61.3
Vibrance Total, 5 fl oz/cwt	233249	10	32	4	3	0	0.6	8 ab	52 a	61.1
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	227325	8	41	3	3	1	0.5	7 a	53 a	61.1
	F, P>F: CV:						5.3, 0.0006	40.0, <0.0001		
							26.4	8.9		

PLANTING DATE #2

Plant population	Total root rot			Aphanomyces root rot	Fusarium root rot	Vascular Necrosis	Wilted plants	Yield	Test Weight	
	Incidence	Severity	Severity Index	Sev. index	Sev. index	% incidence				
7-9 nodes plants/ac	Assessed at early/mid vegetative growth (both fields, 6-8 nodes)						75-90% pod fill	13.5% moisture	lbs/bu	
FIELD 17: May 10; 60.3°F average soil temperature at seeding depth in the first 7 days after planting.										
Non-treated seed	242871	100	96	96	56	39	1.2	58 d*	24 b*	61.0
Obvius, 4.6 fl oz/cwt	263586	100	96	96	64	31	3.0	51 bc	30 a	61.1
Obvius, 4.6 fl oz/cwt + Relenya, 0.4 fl oz/cwt	259327	99	96	96	66	30	3.6	54 cd	30 a	61.2
Vibrance Total, 5 fl oz/cwt	262812	99	96	96	66	30	3.6	47 b	32 a	61.1
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	267749	99	96	94	68	26	1.5	42 a	34 a	60.9
	F, P>F: CV:						24.5, <0.0001	11.3, <0.0001		
							14.6	20.1		

FIELD 18: May 12; 58.6°F average soil temperature at seeding depth in the first 7 days after planting.

Non-treated seed	292433	96	88	85	61	24	1.0	28 d*	28 b*	60.5
Obvius, 4.6 fl oz/cwt	300854	92	86	79	61	18	0.5	21 bc	31 ab	60.4
Obvius, 4.6 fl oz/cwt + Relenya, 0.4 fl oz/cwt	302113	94	87	81	63	18	0.5	22 c	31 ab	60.4
Vibrance Total, 5 fl oz/cwt	293401	94	87	82	62	20	0.8	18 ab	30 ab	60.5
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	298628	92	89	82	63	19	0.7	16 a	32 a	60.5
	F, P>F: CV:						17.8, <0.0001	4.0, 0.0047		
							30.3	13.5		

PLANTING DATE #3

Plant population	Total root rot			Aphanomyces root rot	Fusarium root rot	Vascular Necrosis	Wilted plants	Yield	Test Weight	
	Incidence	Severity	Severity Index	Sev. index	Sev. index	% incidence				
6-9 nodes plants/ac	Assessed at early/mid vegetative growth (Field 17, 7-9 nodes; Field 18, 5-8 nodes)						85-100% pod fill	13.5% moisture	lbs/bu	
FIELD 17: May 22; 56.4°F average soil temperature at seeding depth in the first 7 days after planting.										
Non-treated seed	258359	98	98	96	66	31	3.9	64 c*	18 bc*	61.2
Obvius, 4.6 fl oz/cwt	294078	97	99	96	71	25	5.4	61 bc	21 abc	60.9
Obvius, 4.6 fl oz/cwt + Relenya, 0.4 fl oz/cwt	291949	100	99	99	73	25	3.5	65 c	18 c	59.9
Vibrance Total, 5 fl oz/cwt	294756	100	98	98	72	25	4.8	57 b	22 ab	61.3
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	296208	97	98	95	76	19	3.6	50 a	24 a	59.4
	F, P>F: CV:						17.2, <0.0001	5.6, 0.0004		
							15.5	30.1		

FIELD 18: May 22; 55.3°F average soil temperature at seeding depth in the first 7 days after planting.

Non-treated seed	292046	99	99	98	80	18	1.9	35 c*†	26 c*	62.6
Obvius, 4.6 fl oz/cwt	289045	100	100	99	85	15	2.3	32 bc	29 b	62.5
Obvius, 4.6 fl oz/cwt + Relenya, 0.4 fl oz/cwt	289335	98	100	98	81	17	3.2	35 c	28 bc	62.6
Vibrance Total, 5 fl oz/cwt	297854	100	100	99	87	13	1.8	28 b	30 ab	62.4
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	279849	99	99	99	86	12	2.2	23 a	32 a	62.2
	F, P>F: CV:						15.8, <0.0001	15.8, <0.0001		
							8.5	10.6		

PLANTING DATE #4

Root rot severity was not assessed in the fourth planting date.

Plant population	FIELD 17: June 12-13; 67.6°F ave soil temperature at seeding depth in the first 7 days after planting.			FIELD 18: June 12; 67.0°F average soil temperature at seeding depth in the first 7 days after planting.			
	Wilted plants	Yield	Test Weight	Wilted plants	Yield	Test Weight	
plants/ac	40-85% pod fill	13.5% moisture	lbs/bu	40-85% pod fill	13.5% moisture	lbs/bu	
Non-treated seed	71 b*	9 c*	59.5	301822	91 b*	12 cd*	63.9
Obvius, 4.6 fl oz/cwt	72 ab	9 c	63.5	283818	89 b	14 c	63.7
Obvius, 4.6 fl oz/cwt + Relenya, 0.4 fl oz/cwt	No data	8 c	63.3	294466	92 b	12 d	63.8
Vibrance Total, 5 fl oz/cwt	68 ab	10 b	65.3	302597	85 a	16 b	63.4
Vibrance Total, 5 fl oz + Trebuset, 0.614 fl oz/cwt	61 a	12 a	63.6	302597	84 a	18 a	63.6
	F, P>F: CV:			F, P>F: CV:			
	8.7, <0.0001	18.8, <0.0001	24.3	10.3, <0.0001	42.6, <0.0001	14.2	
	13.9	24.3		7.1	14.2		

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

METHODS – on-farm study conducted near Webster, ND (2025)

GPS coordinates: 48.2368, -98.8791 (plot 101); approximately 3 miles south of Webster, ND

Description: approximately 3 miles south of Webster, ND

PATHOGEN PRESSURE

Native pathogen pressure This study was established in a field that exhibited severe losses to *Aphanomyces* root rot when it was seeded to field peas in 2024. All disease was due to ambient, native pathogen pressure.

Characterization and quantification of the pathogens contributing to observed root rot symptoms: Pathogen diagnostic testing via qPCR was conducted by the National Agricultural Genotyping Center in Fargo, ND. Pathogen diagnostic testing was conducted in the large-plot study, with one sample submitted from each field pea variety in each experimental replicate in each planting date of the study (total 8 samples submitted for testing per variety). Epicotyl sections were excised in conjunction with root rot severity assessments. Each sample consisted of 2, 6, or 7 sections of diseased epicotyl tissue, each 1 cm long. Disease tissue characteristic of typical disease symptoms observed in the corresponding plot was selected. For PG Greenback, Iconic, AAC Julis and Salamanca, the epicotyl tissue sample consisted of one epicotyl section from each of the each of the seven plots with different seed treatments tested on that variety within the corresponding experimental replicate (total of 7 epicotyl sections). For AAC IronHorse, the epicotyl tissue sample consisted of three epicotyl sections (planting date #1) or one epicotyl section (planting date #2) from each of the each of the two plots with different seed treatments tested on that variety within the corresponding experimental replicate (total of 2 or 6 epicotyl sections).

Average pathogen levels in symptomatic epicotyl tissue as detected by qPCR across the full study (5 field pea varieties, 2 planting dates) are presented below. For detailed results broken down by planting date, field pea variety, and sample, see the tab labeled 'pathogen diagnostic testing'.

Aphanomyces euteiches: 24,386,018 target copies per gram of epicotyl tissue

Fusarium acuminatum: 46,602 target copies per gram of epicotyl tissue

Fusarium avenaceum: 250 target copies per gram of epicotyl tissue

Phoma medicaginis: 0 target copies per gram of epicotyl tissue

Pythium spp. 0 target copies per gram of epicotyl tissue

Rhizoctonia solani: 214,981 target copies per gram of epicotyl tissue

Fusarium oxysporum: 24,510 target copies per gram of epicotyl tissue

Fusarium redolens: 27,996 target copies per gram of epicotyl tissue

Fusarium solani: 176 target copies per gram of epicotyl tissue

Interpretation of the results: The results suggest that *Aphanomyces* was a major contributor to the observed native pathogen pressure in this study, *Rhizoctonia* was a moderate contributor to the observed native pathogen pressure in this study, and *Fusarium* was a minor contributor to the native pathogen pressure in this study. The low levels of *F. oxysporum* suggest that *Fusarium oxysporum* vascular wilt was not an important contributor to the observed differences in field pea wilt, vigor or yield. The qPCR testing did not detect any *Pythium*, but the sampling was not conducted in a manner that would have permitted proper quantification of the levels of *Pythium* pressure. *Pythium* spp. primarily causes seed decay and damping-off in field peas, not root rot in established plants. To detect *Pythium*, testing would need to be conducted on seeds and germinating seeds exhibiting seed decay and damping-off.

AGRONOMICS:

Previous crop field peas followed by a cover crop

Tillage This study was direct-seeded into residues of a cover crop seeded the previous fall. The cooperating grower managed this field under conventional tillage.

Experimental design: Small-plot variety screening: Randomized complete block with a split-plot arrangement; main factor = field pea variety, sub-factor = fungicide seed treatment. Number of experimental replicates = 5. Large-plot study: Randomized complete block with a split-split-plot arrangement; main factor = planting date, sub-factor = field pea variety, sub-sub-factor = fungicide seed treatment. Number of experimental replicates = 4.

Fertility: No fertilizer was applied. Granular *Rhizobium* inoculant was applied in-furrow with the seed at planting in accordance with the manufacturer's application instructions. *Rhizobium* inoculant brand: Lalfix Start Spherical Pulses. Manufacturer: Lallemand Plant Care. Type: granular. Active ingredients (<1% w/w): 7.5×10^7 CFU/g *Rhizobium leguminosarum* bv. viciae, 7.5×10^7 CFU/g *Mesorhizobium ciceri*, 5.0×10^7 CFU/g *Bacillus velezensis*. Other ingredients (>99% w/w): an undefined carrier. Application rate: 7.36 lb/ac. The manufacturer's recommended application rate for the 7.5-inch row spacing utilized: 3.55 lb/ac

Row spacing: Plots consisted of 7 rows, each 7.5 inches apart

Planter type: Cone-type planter

Plot size: Large-plot study: 150 feet x 5 feet at seeding; average 134.5 feet at harvest. The field pea varieties Salamanca, Iconic, AAC Julis, and PG Greenback were seeded in blocks 35 feet wide x 150 feet long in each replicate of each planting date, with the 35-foot wide block consisting of 7 strips, each 5 feet wide, planted to non-treated seed or seed treated with one of six different fungicide seed treatments.

Small-plot study: 30 feet x 5 feet at seeding; average 21.5 feet at harvest. All varieties were seeded in blocks 10 feet wide x 30 feet long in each experimental replicate, with the 10-foot wide block consisting of 2 plots, each 5 feet wide, planted to non-treated seed or seed treated with seed treated with the fungicide seed treatments 'VibranceMaxx Pulses RTA' @ 5.0 fl oz/cwt + 'Vayantis' @ 0.1 fl oz/cwt.

Seeding rate: 330,000 viable seeds/ac.

Planting date, seeding depth: The first planting date (May 4) was one of the first days that soils had dried enough to permit planting. This date corresponded to the start of planting in this area; the cooperating producer seeded the surrounding field to wheat the same day, and few, if any, of the neighboring fields had been seeded by this date. By the second planting date (May 12-13), most of the neighboring fields had been seeded.

- Early planting date, small-plot study: May 4, 10:00 am - noon. Seeding depth = approx. 2.0-2.5 inches. We had significant problems with the planter plugging due to very high soil moisture at this seeding depth. This resulted in skipped rows in many plots; due to the skipped rows, this planting date of this study was abandoned.
- Early planting date, large-plot study: May 4, noon - 8:30 pm. Seeding depth = approx. 1.5 inches. The shallower seeding depth eliminated the problems with plugging, resulting in a successful planting.
- Late planting date, small-plot study: May 12, 3:30-4:30 pm Seeding depth = approx. 2.0 inches.
- Late planting date, large-plot study: May 12, 7:00-10:00 pm (replicates 1 and 2); May 13, 8:30-11:30 am (replicates 3 and 4). Seeding depth = approx. 2.0 inches.

Soil temperature: Soil temperature assessment methods: WatchDog B100 temperature data logger soil temperature sensors (Spectrum Technologies; Aurora, IL) programmed to record soil temperatures once every 2 hours were installed in non-harvested guard plots within each experimental replicate of each planting date (total 4 sensors per planting date). Sensors were installed approx. 2 inches below the surface immediately after planting.

Average soil temperature, first 7 days after planting: 58.0°F for the first planting date, 51.2°F for the second planting date.

Average soil temperature, first 30 days after planting: 58.0°F for the first planting date, 58.4°F for the second planting date.

PEST MANAGEMENT

Weed management

- Pre-emergence herbicide, planting date #1: Aquesta 4F (sulfentrazone, 4 lbs a.i./gal) @ 4 fl oz/ac + Glory (metribuzin, 75% by weight) @ 4 oz/ac + Buchaneer 5 Extra (glyphosate, 5.4 lbs/gal of its isopropylamine salt, equivalent to 4.0 lbs/gal of the acid; Tenkoz, Inc., Alpharetta, GA), 32 fl oz/ac + 2.5% v/v ClassAct NG (ammonium sulfate, 50.5%; Winfield Solutions, River Falls, WI) applied on May 7 in 20 gal/ac
- Pre-emergence herbicide, planting date #2: Not applied. We drove to the site to apply the PRE herbicide shortly after planting but had to return without spraying due to unexpectedly strong winds.
- Post-emergence grass herbicide, planting date #1: Targa (quizalofop-p-ethyl, 0.88 lb ai/gal; Gowan Corp., Yuma, AZ) @ 12 fl oz/ac + COC @ 12 fl oz/ac, applied June 26 in 20 gal/ac. This application was made late when foxtail was already several inches tall. Because the peas were entering bloom, clethodim was not applied.
- Post-emergence grass herbicide, planting date #2: Targa (quizalofop-p-ethyl, 0.88 lb ai/gal; Gowan Corp., Yuma, AZ) @ 12 fl oz/ac + Trizenta 3EC (clethodim, 3 lbs ai/gal; Arysta LifeScience, Cary, NC) @ 5 fl oz/ac + COC @ 12 fl oz/ac, applied June 26 in 20 gal/ac
- Post-emergence broadleaf herbicide, planting date #1: Not applied.
- Post-emergence broadleaf herbicide, planting date #2: Basagran (sodium salt of bentazon, 4 lbs ai/gal; Arysta LifeScience Cary, NC) @ 12 fl oz/ac + Metalis 21.3 fl oz/ac (S-metolachlor, 7.62 lbs a.i./gal) + MSO @ 24 fl oz/ac + AMS 8.5 lbs/100 gal, applied July 2 in 15 gal/ac
- Significant supplemental hand weeding was conducted throughout the season.

Weed management was not satisfactory as field peas entered mid to late pod-fill. Windy conditions during May and June resulted in a limited number of days with acceptable wind conditions. Wind conditions were similar in Webster and Carrington; the days with acceptable conditions for spraying were the same across sites. With only one sprayer available for our plot research, we often had to complete our spraying in Carrington on the days with acceptable wind conditions, limiting our ability to accomplish timely spraying at this on-farm study near Webster. To ensure that this problem does not occur again, we are adding a second plot sprayer to our program. In the winter 2025-26, we are building a second sprayer and procuring the associated tractor such that we will be able to make applications in Carrington and on-farm sites on the same days using different sprayers.

IN-SEASON NOTES

Wilt: Large-plot study: The percent of plants exhibiting wilt symptoms was visually estimated on July 16-17 when 90-100% of pods were fully filled in planting date #1 and on July 23 when 87-100% of pods were fully filled in planting date #2. Small-plot study: The percent of plants exhibiting wilt symptoms was visually estimated on July 21 when 90-100% of pods were fully filled.

Vigor: Large-plot study: Assessed as a percentage relative to optimal (perfect) vigor. Assessments were made on July 16-17 when 90-100% of pods were fully filled in planting date #1 and on July 24 when 87-100% of pods were fully filled in planting date #2. Small-plot study: The percent of plants exhibiting wilt symptoms was visually estimated on July 21 when 90-100% of pods were fully filled.

Active nodulation: Active Rhizobium nodulation only assessed in the large-plot study. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on JPlants were dug on June 8 when peas had 7-8 nodes and washed & evaluated on June 10-11. Planting date #2: Plants were dug on June 25 when peas had 8-10 nodes and were washed & evaluated on June 27. Roots were washed carefully, and the percent of nodules that had the fleshy, pink appearance characteristic of active nodules engaged in nitrogen fixation was visually evaluated. For each plot, the number of plants in which approximately 0%, 1-33%, 34-67%, 68-99% and 100% of the nodules appeared active was recorded. On average, 14 plants were evaluated per plot.

Root rot assessments: Root rot severity was only assessed in the large-plot study. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on June 8 when peas had 7-8 nodes and washed & evaluated for root rot severity on June 10-11. Planting date #2: Plants were dug on June 25 when peas had 8-10 nodes and were washed & evaluated for root rot severity on June 27. The length of the epicotyl plus top 2.5 cm of the tap root was recorded for 3 representative plants per plot. The length that was diseased along this length was recorded on an average 14 plants per plot.

HARVEST:

Harvest date: August 19-20, 2025. Harvested with a Zurn plot combine equipped with a Harvestmaster system. The Harvestmaster system provides accurate assessments of yield but not test weight or moisture. A subsample was taken from each plot and assessed for moisture on a calibrated GAC benchtop grain quality assessment unit (Dickey-John; Auburn, IL) and assessed for protein and test weight on a calibrated FOSS benchtop grain quality assessment unit (FOSS North America; Eden Prairie, MN).

Seed yield and quality: Yields were calculated on the basis of a 5-ft plot width and the measured plot length, and seed moisture was assessed after grain was cleaned. Seed yield and test weight were adjusted from the grain actual moisture to a standard 13.5% moisture level.

STATISTICAL ANALYSIS

Analysis of variance Data were evaluated with analysis of variance. (1) The assumption of constant variance was assessed with Levene's test for homogeneity of variances and visually confirmed by plotting residuals against predicted values. (2) The assumption of normality was assessed the Shapiro-Wilk test and visually confirmed with a normal probability plot. (3) The assumption of additivity of main-factor effects across replicates (no replicate-by-treatment interaction) was evaluated with Tukey's test for nonadditivity. If data did not meet model assumptions, a systematic natural-log transformation was applied to correct deviations from normality and/or homoskedasticity, and analysis of variance was conducted on the transformed data. Data subjected to a systematic natural-log transformation are identified by the symbol '‡' placed at the top of the applicable column of data in the summary table; for ease of transformation, treatments for non-transformed data are presented in the summary table. 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 UNIVARIATE and PROC GLM of SAS (version 9.4; SAS Institute, Cary, NC).

METHODS – on-farm study conducted near Makoti, ND (2025)

GPS coordinates: 47.8329, -101.8832; northeast corner of study (plot 101 of small-plot study)

Description: approximately 12 miles southwest of Makoti, ND

PATHOGEN PRESSURE

Native pathogen pressure This study was established in a field with a long history of field pea and lentil production; losses to *Aphanomyces* root rot were observed the last time these crops were grown. All disease was due to native pathogen pressure.

Characterization and quantification of the pathogens contributing to observed root rot symptoms: Pathogen diagnostic testing via qPCR was conducted by the National Agricultural Genotyping Center in Fargo, ND. Pathogen diagnostic testing was conducted in the large-plot study, with one sample submitted from each field pea variety in each experimental replicate in each planting date of the study (total 8 samples submitted for testing per variety). Epicotyl sections were excised in conjunction with root rot severity assessments. Each sample consisted of 2, 6, or 7 sections of diseased epicotyl tissue, each 1 cm long. Disease tissue characteristic of typical disease symptoms observed in the corresponding plot was selected. For PG Greenback, Iconic, AAC Julius and Salamanca, the epicotyl tissue sample consisted of one epicotyl section from each of the each of the seven plots with different seed treatments tested on that variety within the corresponding experimental replicate (total of 7 epicotyl sections). For AAC IronHorse, the epicotyl tissue sample consisted of three epicotyl sections from each of the each of the two plots (planting date #1) or one epicotyl section from each of the two plots (planting date #2) with different seed treatments tested on that variety within the corresponding experimental replicate (total of 2 or 6 epicotyl sections).

Average pathogen levels in symptomatic epicotyl tissue as detected by qPCR across the full study (5 field pea varieties, 2 planting dates) are presented below. For detailed results broken down by planting date, field pea variety, and sample, see the tab labeled 'pathogen diagnostic testing'.

Aphanomyces euteiches: 3,992,473 target copies per gram of epicotyl tissue

Fusarium acuminatum: 0 target copies per gram of epicotyl tissue

Fusarium avenaceum: 0 target copies per gram of epicotyl tissue

Phoma medicaginis: 0 target copies per gram of epicotyl tissue

Pythium spp. 0 target copies per gram of epicotyl tissue

Rhizoctonia solani: 25,819 target copies per gram of epicotyl tissue

Fusarium oxysporum: 16,816 target copies per gram of epicotyl tissue

Fusarium redolens: 22,417 target copies per gram of epicotyl tissue

Fusarium solani: 0 target copies per gram of epicotyl tissue

Interpretation of the results: The results suggest that *Aphanomyces* was a major contributor to the observed native pathogen pressure in this study and that *Rhizoctonia* and *Fusarium* were minor contributors to the observed native pathogen pressure in this study. The low levels of *F. oxysporum* suggest that *Fusarium oxysporum* vascular wilt was not an important contributor to the observed differences in field pea wilt, vigor or yield. The qPCR testing did not detect any *Pythium*, but the sampling was not conducted in a manner that would have permitted proper quantification of the levels of *Pythium* pressure. *Pythium* spp. primarily causes seed decay and damping-off in field peas, not root rot in established plants. To detect *Pythium*, testing would need to be conducted on seeds and germinating seeds exhibiting seed decay and damping-off.

AGRONOMICS:

Previous crop hard red winter wheat (2024). The last time peas or lentils were grown in this field was 2022, when field peas were grown.

Tillage Long-term no-till

Experimental design: Small-plot variety screening: Randomized complete block with a split-plot arrangement; main factor = field pea variety, sub-factor = fungicide seed treatment. Number of experimental replicates = 5. Each planting date was established as a separate study. Large-plot study: Randomized complete block with a split-split-plot arrangement; main factor = planting date, sub-factor = field pea variety, sub-sub-factor = fungicide seed treatment. Number of experimental replicates = 4.

Soil fertility Nitrogen, 26 lbs/ac in the top 12 inches (13 lbs/ac at 0-6 in. deep, 13 lbs/ac at 6-12 in. deep); phosphorous, 14 ppm; potassium, 182 ppm; chloride, 3 lbs/ac at 0-6 in. deep and 3 lbs/ac at 6-12 in. deep; sulfur, 12 lbs/ac at 0-6 in. deep and 12 lbs/ac at 6-12 in. deep; cooper, 0.53 ppm; organic matter, 4.4%; soluble salts, 0.12 mmho/cm at 0-6 in. deep and 0.17 mmho/cm at 6-12 in. deep. organic matter, 4.4%; pH, 0-6 in. deep = 6.4; pH, 6-12 in. deep = 7.5

Soil texture medium soil texture: loam; 45% sand, 38% silt, 17% clay

Fertility: No fertilizer was applied. Granular Rhizobium inoculant was applied in-furrow with the seed at planting in accordance with the manufacturer's application instructions. Rhizobium inoculant brand: Lalfix Start Spherical Pulses. Manufacturer: Lallemand Plant Care. Type: granular. Active ingredients (<1% w/w): 7.5×10^7 CFU/g *Rhizobium leguminosarum* bv. viciae, 7.5×10^7 CFU/g *Mesorhizobium ciceri*, 5.0×10^7 CFU/g *Bacillus velezensis*. Other ingredients (>99% w/w): an undefined carrier. Application rate: 7.36 lb/ac. The manufacturer's recommended application rate for the 7.5-inch row spacing utilized: 3.55 lb/ac

Row spacing: Plots consisted of 7 rows, each 7.5 inches apart

Planter type: Cone-type planter

Plot size: Large-plot study: 150 feet x 5 feet at seeding; average 142.0 feet at harvest. The field pea varieties Salamanca, Iconic, AAC Julius, and PG Greenback were seeded in blocks 35 feet wide x 150 feet long in each replicate of each planting date, with the 35-foot wide block consisting of 7 strips, each 5 feet wide, planted to non-treated seed or seed treated with one of six different fungicide seed treatments.

Small-plot study: 30 feet x 5 feet at seeding; average 23.6 feet at harvest. All varieties were seeded in blocks 10 feet wide x 30 feet long in each experimental replicate, with the 10-foot wide block consisting of 2 plots, each 5 feet wide, planted to non-treated seed or seed treated with seed treated with the fungicide seed treatments 'VibranceMaxx Pulses RTA' @ 5.0 fl oz/cwt + 'Vayantis' @ 0.1 fl oz/cwt.

Seeding rate: 330,000 viable seeds/ac.

Planting date, seeding depth: Commentary on first planting date (April 25): This date corresponded to the start of significant planting in this area; approximately 10-15% of fields had been planted by this date. Commentary on the second planting date (May 11 and 13): By the second planting date, most of the neighboring fields had been seeded.

- Early planting date, small-plot study: April 25, 10:00 am - noon. Seeding depth = approx. 1.6 inches. A relatively shallow planting date was utilized on April 25 because soil moisture was high, and deeper planting would have increased planting problems (plugged rows).
- Early planting date, large-plot study: April 25, noon to 8:00 pm. Seeding depth = approx. 1.6 inches. A relatively shallow planting date was utilized on April 25 because soil moisture was high, and deeper planting would have increased planting problems (plugged rows).

- Late planting date, small-plot study: May 11, 1:00-2:30 pm, and May 13, 4:30-5:30 pm. The first four planter passes of the small-plot variety screening were seeded on May 11. Planting was not finished that day due to problems with the planter that could not be resolved on-site, and planting was finished on May 13. Seeding depth = approx. 2 inches.
- Late planting date, large-plot study: May 13, 5:30-9:30 pm. Seeding depth = approx. 2 inches.

Soil temperature: Soil temperature assessment methods: WatchDog B100 temperature data logger soil temperature sensors (Spectrum Technologies; Aurora, IL) programmed to record soil temperatures once every 2 hours were installed in non-harvested guard plots within each experimental replicate of each planting date (total 4 sensors per planting date). Sensors were installed approx. 2 inches below the surface immediately after planting. The reported soil temperatures in the first 7 days and first 30 days after planting are the average values across four soil sensors (planting date #1) and three soil sensors (planting date #2); one of the four soil sensors installed in the second planting date failed during the growing season.

Average soil temperature, first 7 days after planting: 47.3°F for the first planting date, 47.1°F for the second planting date.

Average soil temperature, first 30 days after planting: 51.8°F for the first planting date, 54.4°F for the second planting date.

PEST MANAGEMENT

Weed management Pre-emergence herbicide, planting date #1: Aquesta 4F (sulfentrazone, 4 lbs a.i./gal) @ 4 fl oz/ac + Glory (metribuzin, 75% by weight) @ 4 oz/ac applied on April 25 in 20 gal/ac

Very windy conditions in spring 2025 resulted in a limited number of days with wind conditions that were acceptable for conducting applications to a planting date study, in which even trace levels of drift cannot extend beyond the 5-foot-wide guard plots established on the edge of each planting date. Weed pressure was very low in this study, and hand weeding was conducted as needed throughout the season to maintain acceptable weed management. We only had one plot sprayer in 2025 and had to prioritize where we sprayed (Carrington, this on-farm site or the other field pea root rot on-farm study near Webster) on the limited number of days with acceptable wind conditions. To avoid this problem in 2026, we are currently in the process of purchasing a tractor that can be utilized for plot sprayer and refurbishing a sprayer to be utilized with that tractor. In 2026, we will have the ability to make pesticide applications both in Carrington and at on-farm sites concurrently.

Supplemental hand weeding was conducted throughout the season.

IN-SEASON NOTES

Wilt: The percent of plants exhibiting wilt symptoms was visually estimated on July 15 when 95-98% of pods were fully filled in planting date #1 and on July 25 when 95-98% of pods were fully filled in planting date #2.

Vigor: Assessed as a percentage relative to optimal vigor. Assessments were made on July 15 when 95-98% of pods were fully filled in planting date #1 and on July 25 when 95-98% of pods were fully filled in planting date #2.

Active nodulation: Active Rhizobium nodulation only assessed in the large-plot study. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on June 26 when peas were at early bloom and washed & evaluated on June 30. Planting date #2: Plants were dug on June 26 when peas had 8-11 nodes and were washed & evaluated on June 30. Roots were washed carefully, and the percent of nodules that had the fleshy, pink appearance characteristic of active nodules engaged in nitrogen fixation was visually evaluated. For each plot, the number of plants in which approximately 0%, 1-33%, 34-67%, 68-99% and 100% of the nodules appeared active was recorded. On average, 13.7 plants were assessed per plot.

Root rot assessments: Root rot severity was only assessed in the large-plot study. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on June 3 when peas had 3-6 nodes and washed & evaluated for root rot severity on June 6. Planting date #2: Plants were dug on June 26 when peas had 8-11 nodes and were washed & evaluated for root rot severity on June 30. The length of the epicotyl plus top 2.5 cm of the tap root was recorded for 3 representative plants per plot. The length that was diseased along this length was recorded. On average, 13.6 plants were assessed per plot.

HARVEST:

Harvest date:

Small-plot study, planting date #1: August 6

Small-plot study, planting date #2: August 23

Large-plot study, planting date #1: August 6

Large-plot study, planting date #2: August 22

Harvested with a Zurn plot combine equipped with a Harvestmaster system. The Harvestmaster system provides accurate assessments of yield but not test weight or moisture. A subsample was taken from each plot and assessed for moisture on a calibrated GAC benchtop grain quality assessment unit (Dickey-John; Auburn, IL) and assessed for protein and test weight on a calibrated FOSS benchtop grain quality assessment unit (FOSS North America; Eden Prairie, MN).

Seed yield and quality: Yields were calculated on the basis of a 5-ft plot width and the measured plot length, and seed moisture was assessed after grain was cleaned. Seed yield and test weight were adjusted from the grain actual moisture to a standard 13.5% moisture level.

STATISTICAL ANALYSIS

Analysis of variance Data were evaluated with analysis of variance. (1) The assumption of constant variance was assessed with Levene's test for homogeneity of variances and visually confirmed by plotting residuals against predicted values. (2) The assumption of normality was assessed the Shapiro-Wilk test and visually confirmed with a normal probability plot. (3) The assumption of additivity of main-factor effects across replicates (no replicate-by-treatment interaction) was evaluated with Tukey's test for nonadditivity. If data did not meet model assumptions, a systematic natural-log transformation was applied to correct deviations from normality and/or homoskedasticity, and analysis of variance was conducted on the transformed data. Data subjected to a systematic natural-log transformation are identified by the symbol '†' placed at the top of the applicable column of data in the summary table; for ease of transformation, treatments for non-transformed data are presented in the summary table. 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 UNIVARIATE and PROC GLM of SAS (version 9.4; SAS Institute, Cary, NC).

METHODS – Carrington, ND (2025), field 17

GPS coordinates: 47.50171, -99.12297; southwest corner of study (plot 101)

Description: approximately 3 miles north of Carrington, ND

PATHOGEN PRESSURE

Native pathogen pressure This study was established in a field with a long history of field pea and lentil production; losses to *Aphanomyces* root rot were observed the last time these crops were grown. All disease was due to native pathogen pressure. Characterization and quantification of the pathogens contributing to observed root rot symptoms: Pathogen diagnostic testing via qPCR was conducted by the National Agricultural Genotyping Center in Fargo, ND.

Pathogen diagnostic testing was conducted on diseased epicotyl tissue collected from four replicates in planting dates #1 and #2.

Testing was conducted on epicotyl sections excised from field peas exhibiting root rot symptoms characteristic of the typical symptoms observed in that plot. Epicotyl sections were excised in conjunction with root rot severity assessments. For all varieties other than 'AAC Julius' and 'Iconic', two pathogen diagnostic tests were conducted per field pea variety in each of planting dates #1 and #2. Every diagnostic testing sample consisted of 8 sections of epicotyl tissue: 2 epicotyl sections collected from plants grown from non-treated seed + 2 epicotyl sections collected from plants grown from fungicide treated seed (VibranceMaxx Pulses RTA + Vayantis) in each of two different experimental replicates. For the varieties 'AAC Julius' and 'Iconic', four pathogen diagnostic tests were conducted per field pea variety in each of planting dates #1 and #2. Two of the diagnostic tests (per planting date) consisted of 8 sections of epicotyl tissue: 2 epicotyl sections collected from plants grown from non-treated seed + 2 epicotyl sections collected from plants grown from fungicide treated seed (VibranceMaxx Pulses RTA + Vayantis) in each of two different experimental replicates. Two of the diagnostic tests (per planting date) consisted of 14 sections of epicotyl tissue: 1 epicotyl section collected from peas grown from non-treated seed and peas grown from six different fungicide seed treatments in each of two different experimental replicates.

Average pathogen levels in symptomatic epicotyl tissue as detected by qPCR across the full study (13 field pea varieties, planting dates #1 and #2) are presented below. For detailed results broken down by planting date, field pea variety, and sample, see the tab labeled 'pathogen diagnostic testing'.

Aphanomyces euteiches: 13,717,310 target copies per gram of epicotyl tissue

Fusarium acuminatum: 6,800 target copies per gram of epicotyl tissue

Fusarium avenaceum: 2,333 target copies per gram of epicotyl tissue

Phoma medicaginis: 0 target copies per gram of epicotyl tissue

Pythium spp. 423 target copies per gram of epicotyl tissue

Rhizoctonia solani: 40,637 target copies per gram of epicotyl tissue

Fusarium oxysporum: 24,508 target copies per gram of epicotyl tissue

Fusarium redolens: 6,170 target copies per gram of epicotyl tissue

Fusarium solani: 334 target copies per gram of epicotyl tissue

Interpretation of the results: The results suggest that *Aphanomyces* was a major contributor to the observed native pathogen pressure in this study and that *Rhizoctonia* and *Fusarium* were minor contributors to the observed native pathogen pressure in this study. The low levels of *F. oxysporum* suggest that *Fusarium oxysporum* vascular wilt was not an important contributor to the observed differences in field pea wilt, vigor or yield. The qPCR testing detected *Pythium* at only very low levels, but the sampling was not conducted in a manner that would have permitted proper quantification of the levels of *Pythium* pressure. *Pythium* spp. primarily causes seed decay and damping-off in field peas, not root rot in established plants. To properly quantify *Pythium* pressure, testing would need to be conducted on seeds and germinating seeds exhibiting seed decay and damping-off.

AGRONOMICS:

Previous crop Forage barley (2024). The last time peas or lentils were grown in this field was 2021, when field peas were grown.

Significant losses to *Aphanomyces* root rot were experienced when the field was seeded to peas in 2021.

Soil fertility Nitrogen, 23 lbs/ac in the top 18 inches (18 lbs/ac at 0-6 in. deep, 5 lbs/ac at 6-18 in. deep); phosphorous, 44 ppm; potassium, 323 ppm; sulfur, 13 lbs/ac at 0-6 in. deep and 20 lbs/ac at 6-12 in. deep; zinc, 2.59 ppm; boron, 0.75 ppm; soluble salts, 0.26 mmho/cm at 0-6 in. deep and 0.26 mmho/cm at 6-12 in. deep. organic matter, 4.25%; pH, 0-6 in. deep = 7.5; pH, 6-18 in. deep = 8.1

Fertility: No fertilizer was applied. Granular *Rhizobium* inoculant was applied in-furrow with the seed at planting in accordance with the manufacturer's application instructions. *Rhizobium* inoculant brand: Lalfix Start Spherical Pulses. Manufacturer: Lallemand Plant Care. Type: granular. Active ingredients (<1% w/w): 7.5×10^7 CFU/g *Rhizobium leguminosarum* bv. *viciae*, 7.5×10^7 CFU/g *Mesorhizobium ciceri*, 5.0×10^7 CFU/g *Bacillus velezensis*. Other ingredients (>99% w/w): an undefined carrier. Application rate: 7.36 lb/ac. The manufacturer's recommended application rate for the 7.5-inch row spacing utilized: 3.55 lb/ac

Tillage This study was direct-seeded into forage barley stubble in a field that has traditionally been managed with conventional tillage. Experimental design: Randomized complete block with a split-split-plot arrangement; main factor = planting date, sub-factor = field pea variety, sub-sub-factor = fungicide seed treatment. Number of experimental replicates = 6.

Row spacing: Plots consisted of 7 rows, each 7.5 inches apart

Planter type: Cone-type planter

Plot size: 30 feet x 5 feet at seeding; average 22.0 feet at harvest. All varieties were seeded in blocks 10 feet wide x 30 feet long in each experimental replicate, with the 10-foot wide block consisting of 2 plots, each 5 feet wide, planted to non-treated seed or seed treated with seed treated with the fungicide seed treatments 'VibranceMaxx Pulses RTA' @ 5.0 fl oz/cwt + 'Vayantis' @ 0.1 fl oz/cwt.

Seeding rate: 330,000 viable seeds/ac.

Planting date, seeding depth: Commentary on first planting date (April 24): This date corresponded to the start of significant planting in the Carrington area.

Planting date #1: April 24, 9:30 am - 2:00 pm. Seeding depth = 2 inches.

Planting date #2: May 5, 4:15-8:00 pm. Seeding depth = 2 inches.

Planting date #3: May 27, 5:15 -7:30 pm. Seeding depth = 2 inches.

Planting date #4: June 5, 2:15 - 4:50 pm. Seeding depth = 2 inches.

Soil temperature: Soil temperature assessment methods: WatchDog B100 temperature data logger soil temperature sensors (Spectrum Technologies; Aurora, IL) programmed to record soil temperatures once every 2 hours were installed in non-harvested guard plots within each experimental replicate of each planting date (total 4 sensors per planting date). Sensors were installed approx. 2 inches below the surface immediately after planting. The reported soil temperatures in the first 7 days and first 30 days after planting are the average values across three

soil sensors (planting date #1) and four soil sensors (planting dates #2-4); one of the four soil sensors installed in the first planting date failed during the growing season.

Average soil temperature, first 7 days after planting: 44.8°F for the first planting date, 62.9°F for the second planting date, 64.7°F for the third planting date, 61.5°F for the fourth planting date.

Average soil temperature, first 30 days after planting: 52.6°F for the first planting date, 59.6°F for the second planting date, 64.7°F for the third planting date, 68.1°F for the fourth planting date.

PEST MANAGEMENT

Weed management

- Pre-emergence, planting date #1: Aquesta 4F (sulfentrazone, 4 lbs a.i./gal) @ 4 fl oz/ac + Glory (metribuzin, 75% by weight) @ 4 oz/ac + Buchaneer 5 Extra (glyphosate, 5.4 lbs/gal of its isopropylamine salt, equivalent to 4.0 lbs/gal of the acid; Tenkoz, Inc., Alpharetta, GA), 32 fl oz/ac + 2.5% v/v ClassAct NG (ammonium sulfate, 50.5%; Winfield Solutions, River Falls, WI) @ 20gpa applied April 25.
- Pre-emergence, planting date #2: Buccaneer 5 Extra 42froz + ClassAct NG 2.5%v/v + Aquesta 4froz+ Glory 4oz @ 20gpa applied May 7
- Pre-emergence, planting date #3: Buccaneer 5 Extra 42froz + ClassAct NG 2.5%v/v applied May 7; Buccaneer 5 Extra 64froz + ClassAct NG 2.5%v/v + Aquesta 4froz+ Glory 4oz @ 20gpa applied May 27.
- Pre-emergence, planting date #4: Buccaneer 5 Extra 42froz + ClassAct NG 2.5%v/v applied May 7; Buccaneer 5 Extra 64froz + ClassAct NG 2.5%v/v @ 20gpa applied May 27; Aquesta 4froz+ Glory 4oz @ 20 gpa applied June 5.
- Post-emergence grass herbicide: Targa (quizalofop-p-ethyl, 0.88 lb ai/gal; Gowan Corp., Yuma, AZ) + Trizenta 3 EC (clethodim, 3 lb ai/gal) 5froz + COC 12froz @20 gpa applied May 29 in planting dates #1 and #2 and applied June 25 in planting dates #3 and 4.
- Post-emergence broadleaf herbicide: Sprayed Beyond Extra (ammonium salt of imazamox, 1 lb ai/gal; BASF Corp, Raleigh, NC) 4froz+ Basagran 5L (sodium salt of bentazon, 4 lbs ai/gal; Arysta LifeScience North America, Cary, NC) 12froz + Metalis (S-metolachlor, 7.62 lbs a.i./gal) 16froz+COC 12froz + AMS 8.5lbs/100gal applied in 20 gpa on May 30 in planting dates #1 and #2 and applied in 15 gpa on July 2 in planting dates #3 and 4.
- Supplemental hand weeding was conducted throughout the season.

Foliar fungicide: Proline (5.7 fl oz/ac; prothioconazole, 480 grams ai/liter) was applied in 10 gal/ac to planting dates #1 on July 8 and was applied in 12 gal/ac to planting dates #3 and 4 on July 23. This was a preventative fungicide application targeting powdery mildew.

Insecticide: Asana XL (9.6 fl oz/ac; esfenvalerate, 0.66 lbs ai/gal) was applied in 15 gal/ac to the entire study (all planting dates) on July 16. This insecticide application was made at the first appearance of aphids.

IN-SEASON NOTES

Wilt: The percent of plants exhibiting wilt symptoms was visually estimated on July 14 when 90-98% of pods were fully filled in planting date #1; on July 14 when 60-85% of pods were fully filled in planting date #2; on Aug. 1 when 45-95% of pods were fully filled in planting date #3; on Aug. 10 when 35-87% of pods were fully filled.

Active nodulation: Active Rhizobium nodulation was only assessed in planting dates #1 and #2. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on June 11 when peas had 11-12 nodes and were washed & evaluated on June 11-12. Planting date #2: Plants were dug on June 24 when peas had 12-17 nodes and were washed & evaluated on June 26-27. Roots were washed carefully, and the percent of nodules that had the fleshy, pink appearance characteristic of active nodules engaged in nitrogen fixation was visually evaluated. For each plot, the number of plants in which approximately 0%, 1-33%, 34-67%, 68-99% and 100% of the nodules appeared active was recorded. On average, 13.5 plants were assessed per plot.

Root rot assessments: Root rot severity was only assessed in planting dates #1 and #2. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on June 11 when peas had 11-12 nodes and were washed & evaluated on June 11-12. Planting date #2: Plants were dug on June 24 when peas had 12-17 nodes and were washed & evaluated on June 26-27. The length of the epicotyl plus top 2.5 cm of the tap root was recorded for 3 representative plants per plot. The length that was diseased along this length was recorded. On average, 13.5 plants were assessed per plot.

HARVEST:

Harvest date:

- Planting date #1: August 2 and 11
- Planting date #2: August 11-12
- Planting date #3: August 26
- Planting date #4: August 26-27

Harvested with a Zurn plot combine equipped with a Harvestmaster system. The Harvestmaster system provides accurate assessments of yield but not test weight or moisture. A subsample was taken from each plot and assessed for moisture on a calibrated GAC benchtop grain quality assessment unit (Dickey-John; Auburn, IL) and assessed for protein and test weight on a calibrated FOSS benchtop grain quality assessment unit (FOSS North America; Eden Prairie, MN).

Seed yield and quality: Yields were calculated on the basis of a 5-ft plot width and the measured plot length, and seed moisture was assessed after grain was cleaned. Seed yield and test weight were adjusted from the grain actual moisture to a standard 13.5% moisture level.

STATISTICAL ANALYSIS

Analysis of variance Data were evaluated with analysis of variance. (1) The assumption of constant variance was assessed with Levene's test for homogeneity of variances and visually confirmed by plotting residuals against predicted values. (2) The assumption of normality was assessed the Shapiro-Wilk test and visually confirmed with a normal probability plot. (3) The assumption of additivity of main-factor effects across replicates (no replicate-by-treatment interaction) was evaluated with Tukey's test for nonadditivity. If data did not meet model assumptions, a systematic natural-log transformation was applied to correct deviations from normality and/or homoskedasticity, and analysis of variance was conducted on the transformed data. Data subjected to a systematic natural-log transformation are identified by the symbol '†' placed at the top of the applicable column of data in the summary table; for ease of transformation, treatments for non-transformed data are presented in the summary table. 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 UNIVARIATE and PROC GLM of SAS (version 9.4; SAS Institute, Cary, NC).

METHODS – Carrington, ND (2025), field Q9B

GPS coordinates: 47.5153, -99.1292; southeast corner of study (plot 101)

Description: approximately 4 miles north of Carrington, ND

PATHOGEN PRESSURE

Native pathogen pressure This study was established in a field with a long history of field pea and lentil production; losses to *Aphanomyces* root rot were observed the last time these crops were grown. All disease was due to native pathogen pressure.

Characterization and quantification of the pathogens contributing to observed root rot symptoms: Pathogen diagnostic testing via qPCR was conducted by the National Agricultural Genotyping Center in Fargo, ND.

Pathogen diagnostic testing was conducted on diseased epicotyl tissue collected from four replicates in planting dates #1 and #2.

Testing was conducted on epicotyl sections excised from field peas exhibiting root rot symptoms characteristic of the typical symptoms observed in that plot. Epicotyl sections were excised in conjunction with root rot severity assessments. For all varieties other than 'AAC Julius' and 'Iconic', two pathogen diagnostic tests were conducted per field pea variety in each of planting dates #1 and #2. Every diagnostic testing sample consisted of 8 sections of epicotyl tissue: 2 epicotyl sections collected from plants grown from non-treated seed + 2 epicotyl sections collected from plants grown from fungicide treated seed (VibranceMaxx Pulses RTA + Vayantis) in each of two different experimental replicates. For the varieties 'AAC Julius' and 'Iconic', four pathogen diagnostic tests were conducted per field pea variety in each of planting dates #1 and #2. Two of the diagnostic tests (per planting date) consisted of 8 sections of epicotyl tissue: 2 epicotyl sections collected from plants grown from non-treated seed + 2 epicotyl sections collected from plants grown from fungicide treated seed (VibranceMaxx Pulses RTA + Vayantis) in each of two different experimental replicates. Two of the diagnostic tests (per planting date) consisted of 14 sections of epicotyl tissue: 1 epicotyl section collected from peas grown from non-treated seed and peas grown from six different fungicide seed treatments in each of two different experimental replicates.

Average pathogen levels in symptomatic epicotyl tissue as detected by qPCR across the full study (17 field pea varieties, planting dates #1 and #2) are presented below. For detailed results broken down by planting date, field pea variety, and sample, see the tab labeled 'pathogen diagnostic testing'.

Aphanomyces euteiches: 15,787,767 target copies per gram of epicotyl tissue

Fusarium acuminatum: 10,714 target copies per gram of epicotyl tissue

Fusarium avenaceum: 28,959 target copies per gram of epicotyl tissue

Phoma medicaginis: 0 target copies per gram of epicotyl tissue

Pythium spp. 0 target copies per gram of epicotyl tissue

Rhizoctonia solani: 173,606 target copies per gram of epicotyl tissue

Fusarium oxysporum: 8,659 target copies per gram of epicotyl tissue

Fusarium redolens: 5,361 target copies per gram of epicotyl tissue

Fusarium solani: 6 target copies per gram of epicotyl tissue

Interpretation of the results: The results suggest that *Aphanomyces* was a major contributor to the observed native pathogen pressure in this study and that *Rhizoctonia* and *Fusarium* were minor contributors to the observed native pathogen pressure in this study. The low levels of *F. oxysporum* suggest that *Fusarium oxysporum* vascular wilt was not an important contributor to the observed differences in field pea wilt, vigor or yield. The qPCR testing detected *Pythium* at only very low levels, but the sampling was not conducted in a manner that would have permitted proper quantification of the levels of *Pythium* pressure. *Pythium* spp. primarily causes seed decay and damping-off in field peas, not root rot in established plants. To properly quantify *Pythium* pressure, testing would need to be conducted on seeds and germinating seeds exhibiting seed decay and damping-off.

AGRONOMICS:

Previous crop Spring wheat (2024) The last time peas or lentils were grown in this field was 2015, when field peas were grown.

Significant losses to *Aphanomyces* root rot were not experienced when the field was seeded to peas in 2015.

Fertility: No fertilizer was applied. Granular Rhizobium inoculant was applied in-furrow with the seed at planting in accordance with the manufacturer's application instructions. Rhizobium inoculant brand: Lalfix Start Spherical Pulses. Manufacturer: Lallemand Plant Care. Type: granular. Active ingredients (<1% w/w): 7.5×10^7 CFU/g Rhizobium leguminosarum bv. viciae, 7.5×10^7 CFU/g Mesorhizobium ciceri, 5.0×10^7 CFU/g Bacillus velezensis. Other ingredients (>99% w/w): an undefined carrier. Application rate: 7.36 lb/ac. The manufacturer's recommended application rate for the 7.5-inch row spacing utilized: 3.55 lb/ac

Tillage Conventional tillage. Disked in October 2024; cultivated on April 21 and April 23, 2025.

Experimental design: Randomized complete block with a split-split-plot arrangement; main factor = planting date, sub-factor = field pea variety, sub-sub-factor = fungicide seed treatment. Number of experimental replicates = 6.

Row spacing: Plots consisted of 7 rows, each 7.5 inches apart

Planter type: Cone-type planter

Plot size: 30 feet x 5 feet at seeding; average 23.4 feet at harvest. All varieties were seeded in blocks 10 feet wide x 30 feet long in each experimental replicate, with the 10-foot wide block consisting of 2 plots, each 5 feet wide, planted to non-treated seed or seed treated with seed treated with the fungicide seed treatments 'VibranceMaxx Pulses RTA' @ 5.0 fl oz/cwt + 'Vayantis' @ 0.1 fl oz/cwt.

Seeding rate: 330,000 viable seeds/ac.

Planting date, seeding depth: Commentary on first planting date (April 23): This date corresponded to the start of significant planting in the Carrington area.

Planting date #1: April 23, 9:30 am to 12:30 pm. Seeding depth = 2 inches.

Planting date #2: May 5, 10 am to 3:15 pm. Seeding depth = 2 inches.

Planting date #3: May 27, 10 am to 4 pm. Seeding depth = 2 inches.

Planting date #4: June 5, 9:30 am to 12:30 pm. Seeding depth = 2 inches.

Soil temperature: Soil temperature assessment methods: WatchDog B100 temperature data logger soil temperature sensors (Spectrum Technologies; Aurora, IL) programmed to record soil temperatures once every 2 hours were installed in non-harvested guard plots within each experimental replicate of each planting date (total 4 sensors per planting date). Sensors were installed approx. 2 inches below the surface immediately after planting. The reported soil temperatures in the first 7 days and first 30 days after planting are the average values across three soil sensors (planting date #1) and four soil sensors (planting dates #2-4); one of the four soil sensors installed in the first planting date failed during the growing season.

Average soil temperature, first 7 days after planting: 43.2°F for the first planting date, 60.1°F for the second planting date, 63.6°F for the third planting date, 59.5°F for the fourth planting date.

Average soil temperature, first 30 days after planting: 51.9°F for the first planting date, 58.8°F for the second planting date, 63.7°F for the third planting date, 66.4°F for the fourth planting date.

PEST MANAGEMENT

Weed management

- Pre-plant incorporated, all planting dates: Sonalan (ethalfluralin, 3 lbs a.i./gal) applied at 2 pt/ac on April 21; incorporated April 21 and 23.
- Pre-emergence, planting date #1: Aquesta 4F (sulfentrazone, 4 lbs a.i./gal) @ 4 fl oz/ac + Glory (metribuzin, 75% by weight) @ 4 oz/ac + Buchaneer 5 Extra (glyphosate, 5.4 lbs/gal of its isopropylamine salt, equivalent to 4.0 lbs/gal of the acid; Tenkoz, Inc., Alpharetta, GA), 32 fl oz/ac + 2.5% v/v ClassAct NG (ammonium sulfate, 50.5%; Winfield Solutions, River Falls, WI) @ 20gpa applied April 25.
- Pre-emergence, planting date #2: Aquesta 4froz+ Glory 4oz @ 20gpa applied May 7
- Pre-emergence, planting date #3: Buccaneer 5 Extra 64froz + ClassAct NG 2.5%v/v applied May 27; Buccaneer 5 Extra 64froz + ClassAct NG 2.5%v/v + Aquesta 4froz+ Glory 4oz @ 20gpa applied May 28.
- Pre-emergence, planting date #4: Buccaneer 5 Extra 42froz + ClassAct NG 2.5%v/v applied May 27; Buccaneer 5 Extra 64froz + ClassAct NG 2.5%v/v @ 20gpa applied May 27; Aquesta 4froz+ Glory 4oz @ 20 gpa applied June 5.
- Post-emergence grass herbicide: Targa (quizalofop-p-ethyl, 0.88 lb ai/gal; Gowen Corp., Yuma, AZ) + Trizenta 3 EC (clethodim, 3 lb ai/gal) 5froz + COC 12froz @20 gpa applied May 30 in planting dates #1 and #2 and applied June 25 in planting date #3
- Post-emergence broadleaf herbicide: Sprayed Beyond Extra (ammonium salt of imazamox, 1 lb ai/gal; BASF Corp, Raleigh, NC) 4froz+ Basagran 5L (sodium salt of bentazon, 4 lbs ai/gal; Arysta LifeScience North America, Cary, NC) 12froz + Metalis (S-metolachlor, 7.62 lbs a.i./gal) 16froz +COC 12froz + AMS 8.5lbs/100gal applied in 15 gpa on July 2 in planting dates #3 and 4.
- Supplemental hand weeding was conducted throughout the season.

Foliar fungicide: Proline (5.7 fl oz/ac; prothioconazole, 480 grams ai/liter) was applied in 10 gal/ac to planting dates #1 on July 8 and was applied in 12 gal/ac to planting dates #3 and 4 on July 23. The target of this application was *Ascochyta* blight and powdery mildew.

Insecticide: Asana XL (9.6 fl oz/ac; esfenvalerate, 0.66 lbs ai/gal) was applied in 15 gal/ac to the entire study (all planting dates) on July 16 at the first sign of aphids.

IN-SEASON NOTES

Wilt: The percent of plants exhibiting wilt symptoms was visually estimated on July 14 when 80-95% of pods were fully filled in planting date #1; on July 14 when 50-70% of pods were fully filled in planting date #2; on Aug. 4 when 60-85% of pods were fully filled in planting date #3; on Aug. 14, 15, and 25 when 65-100% of pods were fully filled.

Active nodulation: Active Rhizobium nodulation was only assessed in planting dates #1 and #2. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on June 12-13 when peas had 9-12 nodes and were washed & evaluated on June 13 and 16-17. Planting date #2: Plants were dug on June 19 when peas had 10-12 nodes and were washed & evaluated on June 20 and 23-26. Roots were washed carefully, and the percent of nodules that had the fleshy, pink appearance characteristic of active nodules engaged in nitrogen fixation was visually evaluated. For each plot, the number of plants in which approximately 0%, 1-33%, 34-67%, 68-99% and 100% of the nodules appeared active was recorded. On average, 13.0 plants were assessed per plot (planting date #1) and 12.7 plants were assessed per plot (planting date #2).

Root rot assessments: Root rot severity was only assessed in planting dates #1 and #2. Roots were collected from each end of plots outside of the area assessed for yield. Planting date #1: Plants were dug on June 12-13 when peas had 9-12 nodes and were washed & evaluated on June 13 and 16-17. Planting date #2: Plants were dug on June 19 when peas had 10-12 nodes and were washed & evaluated on June 20 and 23-26. The length that was diseased along the epicotyl and top 2.5-cm length of the tap root was recorded for every plant, and the total length of the epicotyl plus top 2.5 cm of the tap root was recorded for 3 representative plants per plot. Root rot severity was calculated by dividing the average length diseased for each plot by the average length of the epicotyl plus tap root for that planting date in the corresponding experimental replicate. On average, 13.0 plants were assessed per plot (planting date #1) and 12.7 plants were assessed per plot (planting date #2).

Vascular necrosis: The percent of plants exhibiting vascular necrosis characteristic of colonization by the *Fusarium oxysporum* wilt pathogen was visually estimated on July 14 when 80-95% of pods were fully filled in planting date #1; on July 14 when 50-70% of pods were fully filled in planting date #2; on Aug. 4 when 60-85% of pods were fully fill. On roots in which the epicotyl tissue was not diseased 1 cm below the trifid bract, the transverse cut was made through the epicotyl tissue 1 cm below the trifid bract and visually examined for brown-red discoloration in the vascular cylinder (xylem tissues). The incidence of plants exhibiting vascular discoloration in the epicotyl was recorded.

HARVEST:

Harvest date: Planting date #1: August 12-13; Planting date #2: August 25; Planting date #3: August 27, 29; Planting date #4: Sept. 2, 8, 9

Harvest and quality assessment: Harvested with a Zurn plot combine equipped with a Harvestmaster system. The Harvestmaster system provides accurate assessments of yield but not test weight or moisture. A subsample was taken from each plot and assessed for moisture on a calibrated GAC benchtop grain quality assessment unit (Dickey-John; Auburn, IL) and assessed for protein and test weight on a calibrated FOSS benchtop grain quality assessment unit (FOSS North America; Eden Prairie, MN).

Yield calculations: Yields were calculated on the basis of a 5-ft plot width and the measured plot length, and seed moisture was assessed after grain was cleaned. Seed yield was adjusted from the grain actual moisture to a standard 13.5% moisture level.

STATISTICAL ANALYSIS

Analysis of variance Data were evaluated with analysis of variance. (1) The assumption of constant variance was assessed with Levene's test for homogeneity of variances and visually confirmed by plotting residuals against predicted values. (2) The assumption of normality was assessed the Shapiro-Wilk test and visually confirmed with a normal probability plot. (3) The assumption of additivity of main-factor effects across replicates (no replicate-by-treatment interaction) was evaluated with Tukey's test for nonadditivity. If data did not meet model assumptions, a systematic natural-log transformation was applied to correct deviations from normality and/or homoskedasticity, and analysis of variance was conducted on the transformed data. Data subjected to a systematic natural-log transformation are identified by the symbol '‡' placed at the top of the applicable column of data in the summary table; for ease of transformation, treatments for non-transformed data are presented in the summary table. 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 UNIVARIATE and PROC GLM of SAS (version 9.4; SAS Institute, Cary, NC).