Oakes Irrigation Research Site

Robert Titus Research Farm

Carrington Research Extension Center

North Dakota State University

Garrison Diversion Conservancy District

2017 ANNUAL REPORT

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NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

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Annual reports for 1996-2017 are available at www.ag.ndsu.nodak.edu/oakes/oakes.htm

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Oakes Irrigation Research Site - Updates

Kelly Cooper

The Oakes Irrigation Research Site, Robert Titus Research Farm utilizes its unique geographical location, abundant water supply, and well-drained, productive soils to conduct research and supply educational opportunities. In 2017 the irrigated and dryland portions of the farm focused in part on varietal performance evaluations of corn, soybeans and dry beans. Fungal and bacterial diseases of peas, dry beans, soybeans, and potatoes were also evaluated in regards to fungicide timing, irrigation management, and fungicide types. Fertility studies have long been a part of the studies and continued through 2017 with the continuous strip till corn nitrogen rate trial, the corn/soybean rotation strip till trial, and several soybean trials. Herbicide effects on daughter tubers was another ongoing trial in 2017. In the interest of soil health and the need to refine efficient economic conservation practices the Oakes site became involved in a managed livestock grazing system. The Oakes site strives to bring relevant current information to local producers and also production practices and crops that may be important in the future.

I want to personally thank Leonard Besemann for his many years of hard work and dedication to the research site. Leonard is a man of many talents and was instrumental in all aspects of the plot research. We wish him a very happy and enjoyable retirement.

Figure 1. Strip tilling for corn.

Oakes Irrigation Research Site - Updates

Kelly Cooper

Figure 2. Our new Lateral with Variable Rate Irrigation capability.

RESEARCH PROGRAM

Data on irrigated crop production have been collected for the past 47 years at the Oakes Irrigation Research Site located on the Robert Titus farm. In 2016 the site increased in size to about 40 acres due to the foresight and generosity of Robert Titus. The site is located 4.5 miles south of Oakes adjacent to North Dakota State Highway 1. The objectives of these studies are to:

1. Provide irrigators with information that results in efficient crop production.

2. Develop and refine Best Management Practices that are producer acceptable.

3. Promote irrigation development in North Dakota.

4. Determine alternate and specialty crops to be grown under irrigation in North Dakota and develop agronomic practices for their successful adaptation.

A cooperative agreement between North Dakota State University and the Garrison Diversion Conservancy District makes this research effort possible. The University provides technical staff: Kelly Cooper, research agronomist; Leonard Besemann, research specialist; and Heidi Eslinger, research technician. The Garrison Diversion Conservancy District provides most of the financial support. North Dakota State University faculty and staff from the departments of Soil Science, Plant Science, Agricultural and Biosystems Engineering, Plant Pathology, and the Agricultural Experiment Station participate in conducting experiments at the site.

WEATHER 2017

The winter of 2016 - 2017 was non-eventful. Temperatures followed a typical winter in North Dakota with warm and cool temperatures through the winter months with no extremes. The amount of snow received for the winter was less than the long-term average. Most field work and planting dates were ahead or near seasonal averages. The last frost in the spring was on May 2. The maximum temperature equaled or exceeded 90°F eleven times; four times in June, six times in July and once in September. The high temperature of 97°F occurred twice; July 11 and July 17. Precipitation was below the long-term average in April, May, June, July and October. Precipitation was above the long-term average in August and September. The total rainfall for the season was about six inches below the long-term average (April to October). The mean daily temperatures were nearly the same as the long-term averages for the season except for August, which was four degrees below the long-term average. The first frost, October 9, was also the first hard frost (≤ 28°F). All crops reached maturity before frost. Growing degree units in 2017 were below the long-term average.

Table 1. Precipitation and temperature at the Oakes Irrigation Research Site.

	Precipitation			Average daily temperatures		
Month	2017	15-year average	25-year average	2017	15-year average	25-year average
	----------inches----------			----------°F----------		
April	1.18	1.54	1.56	44	44	43
May	1.46	3.39	3.06	56	56	56
June	2.14	4.46	4.10	67	67	67
July	0.88	2.55	3.16	72	71	71
August	3.86	2.60	2.37	65	69	69
September	2.85	2.43	2.75	60	61	60
October	0.74	2.09	2.21	47	47	47

Table 2. Growing degree units[1] at the Oakes Irrigation Research Site.

Month	2017	10-year average	15-year average	25-year average
May	310	306	302	303
June	513	507	505	503
July	648	649	652	639
August	476	583	576	581
September	366	387	384	376
Total	2313	2432	2419	2401

[1]Growing degree units = (Tempmax + Tempmin)/2 - 50. If Tempmax is greater than 86, then Tempmax = 86. If Tempmin is less than 50, then Tempmin = 50. Temperature is in degrees F.

Table 3. Dates of last and first frosts.

	2017	10-year average	15-year average	25-year average
Last frost in Spring				
32 °F or less	2-May	10-May	6-May	4-May
28 °F or less	29-Apr	27-Apr	27-Apr	27-Apr
First frost in Fall				
32 °F or less	9-Oct	4-Oct	4-Oct	2-Oct
28 °F or less	9-Oct	10-Oct	9-Oct	8-Oct
Frost free period (days)	160	147	151	151

Table 4. Irrigation water applied, 2017.

Study	Irrigation water applied
	inches
Dry edible bean variety trials	9.6
Field corn hybrid performance trial	11.9
Optimum corn stover removal for biofuel	
corn on corn	14.0
corn on soybean	14.0
soybean on corn	14.0
Potato trials	14.3
Soybean Sclerotinia study	12.3
Soybean studies	12.3
Soybean variety performance trials	11.9
Soybean studies - Mosaic/Bayer	13.2
Strip-till	
corn on corn	14.0
corn on soybean	14.0
soybean on corn	14.0
Sunflower fungicide drop nozzle study*	9.2

*Received additional irrigation via the misting system.

Figure 3. Watering beans early season.

Dry Edible Bean Variety Trials

K. Cooper, L. Besemann and H. Eslinger

Dry edible beans play a significant role in irrigated rotations in southeastern North Dakota. As universities and private companies develop new varieties it is important to test them upon their release. Seventeen edible bean varieties were tested: six miscellaneous, three navy, and eight pinto.

MATERIALS AND METHODS

Soil:	Gardena loam sandy substratum, Embden sandy loam; pH = 7.1; 2.2% organic matter; soil N was 26 lbs/acre; soil P was high; soil K was very high and soil S was low.
Previous crop:	2016 – soybean.
Seedbed preparation:	Spring conventional tillage.
Planting:	May 26 in 30-inch rows.
Plots:	Plots were 25 ft long by 5 ft (2 rows) wide. The study had four replications.
Fertilizer:	Broadcast 21 lbs N/acre, 40 lbs P_2O_5/acre, 50 lbs K_2O/acre and 15 lbs S/acre as 10-18-23-7 April 4.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest control:	Authority 19 oz/acre (May 19), Select 16 oz/acre + NIS 1 pt/100 gal + Interlock 4 oz/acre (June 20) for weed control. Endura 5.5 oz/acre (July 20) for disease control.
Harvest:	Hand harvested bean varieties September 11 to September 12 as they matured. Harvest area for all bean varieties was five feet (two rows wide) by approximately 19 feet. Beans were threshed with a stationary plot thresher September 14.

RESULTS

The three classes of dry edible beans all had good yields for the 2017 season. The mean yield of the miscellaneous beans was 4223 lbs/acre. Zorro (black bean) had the highest yield of the miscellaneous beans yielding 4827 lbs/acre. The mean yield of the navy beans was 3552 lbs/acre. HMS Medalist had the highest yield of the navy bean yielding 3872 lbs/acre. The mean yield of the pinto beans was 3932 lbs/acre. LaPaz had the highest pinto bean yield at 4249 lbs/acre.

Table 1. Misc Bean Variety Trial at the Oakes Irrigation Research Site in 2017.

Variety	Market Class	Days to PM	Seeds/ Pound	Seed Weight	Test Weight	Seed Yield 2015	2016	2017	3-yr. Avg.
				grams/ 100	lb/bu	------ lb/ac ------			
Eclipse	Black	92.8	2064	22.0	63.1	3529	3130	4256	3638
Merlot	Small Red	96.3	1116	40.7	61.3	3687	3472	3924	3694
Loreto	Black	97.0	2085	21.8	63.6	3844	2734	4023	3534
Zorro	Black	95.8	1950	23.3	64.4	3834	2844	4827	3835
Rosetta	Pink	95.8	1165	39.1	61.8	--	3222	4522	--
Powderhorn	Great Northern	91.5	1173	38.8	58.9	--	--	3787	--
Mean		94.9	1592	30.9	62.2	3649	2899	4223	--
C.V. (%)		1.4	3.8	4.9	0.6	9.4	12.4	12.9	--
LSD 0.10		1.7	75	1.9	0.5	415	431	673	--
LSD 0.05		2.0	91	2.3	0.5	501	520	818	--

Planting Date = May 26; Harvest Date = September 11 and 12; Previous Crop = Soybean

Table 2. Navy Bean Variety Trial at the Oakes Irrigation Research Site in 2017.

Variety	Days to PM	Seeds/ Pound	Seed Weight	Test Weight	Seed Yield 2015	2016	2017	3-yr. Avg.
			grams/100		------- lb/ac -------			
HMS Medalist	95.3	2307	19.7	64.1	3615	2389	3872	3292
Ensign	91.5	2249	20.3	63.7	3345	3050	3230	3209
T9905	95.3	2124	21.4	64.2	3446	3134	3553	3378
Mean	94.0	2226	20.5	64.0	3423	2848	3552	--
C.V. (%)	0.8	2.4	2.2	0.6	5.4	13.7	6.7	--
LSD 0.10	1.0	72	0.6	0.5	235	507	327	--
LSD 0.05	1.3	91	0.8	0.6	287	626	412	--

Planting Date = May 26; Harvest Date = September 11 and 12; Previous Crop = Soybean

Table 3. Pinto Bean Variety Trial at the Oakes Irrigation Research Site in 2017.

Variety	Days to PM	Seeds/ Pound	Seed Weight	Test Weight	Seed Yield 2017	Seed Yield 3-yr. Avg.
			grams/100	lb/bu	------ lb/ac -------	
LaPaz	96.0	1165	39.0	61.9	4249	3618
Lariat	96.8	1011	44.9	61.2	4112	3641
Stampede	93.5	1013	44.9	59.1	3343	3454
Maverick	93.8	1043	43.6	60.5	3651	3352
ND-307	95.0	1004	45.2	59.6	3947	3876
Windbreaker	90.5	1037	43.8	59.3	3985	3827
Palomino	97.0	992	45.8	59.8	4040	--
Monterrey	95.5	1114	40.8	62.5	4134	--
Mean:	94.8	1047	43.5	60.5	3932	--
C.V.(%)	1.3	3.7	3.8	0.7	11.4	--
LSD 0.10	1.5	47	2.0	0.5	548	--
LSD 0.05	1.8	57	2.4	0.6	662	--

Planting Date = May 26; Harvest Date = September 11 and 12; Previous Crop = Soybean

Dry edible bean (misc.) trial.

Corn Hybrid Performance Trial - Irrigated

K. Cooper, L. Besemann and H. Eslinger

Corn for grain commands the most irrigated acres of all crops in North Dakota. The fact that significant differences in the accumulation of growing degree units for corn and other weather-related issues exist across the state, it is vital that corn hybrids be tested in specific locations and regions. It is the goal of this trial to provide yield and other agronomic parameters for corn growers in southeastern North Dakota. This trial tested 44 hybrids.

MATERIALS AND METHODS

Soil:	Overly loam, Gardena loam clayey substratum, Gardena loam sandy substratum; pH = 6.7; 3.4% organic matter; soil N was 36 lbs/acre; soil P was high; soil K was very high; soil S was medium.
Previous crop:	2016 - soybean
Seedbed preparation:	Strip-till with an Orthman strip-till machine.
Planting:	Planted May 5 in 30-inch rows. Thinned to 36,900 plants/acre.
Fertilizer:	Broadcast 21 lbs N/acre, 40 lbs P_2O_5/acre, 50 lbs K_2O/acre and 15 lbs S/acre as 10-18-23-7 April 4. Stream bar 65 lbs N/acre May 23 as 28-0-0. Sidedress 134 lbs N/acre June 16 as 28-0-0.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest Control:	Laudis (3 oz/acre) + AAtrex 9-O (0.5 lb ai/acre) + Destiny (0.05% v/v) + Interlock (4 oz/acre) May 24. Capreno (0.75 oz/acre) June 11.
Harvest:	October 25 with a plot combine. Harvest area was two rows 19 feet long.

RESULTS

The overall mean was 283.5 bu/acre. Yields were high this year and ranged from 245.3 bu/acre to 316.6 bu/acre.

Table 1. Corn hybrid performance trial at the Oakes Irrigation Research Site in 2017.

Brand	Hybrid	RM	Hybrid Traits[1]	Days to Silk	Ear Height	Plant Height	Grain Protein	Content Starch	Content Oil	Moisture	Test Weight	Grain Yield 2017	Grain Yield 2 yr. Avg.
					inch	inch	%	%	%	%	lb/bu	bu/ac	bu/ac
Channel	193-53	93	VT2PRIB	63.8	39.8	90.4	9.0	72.6	3.4	18.1	58.5	271.8	258.2
Channel	195-18	95	VT2PRIB	66.8	39.7	89.3	9.6	72.4	3.3	22.0	57.8	299.8	--
Channel	197-50	97	VT2PRIB	66.5	45.5	96.0	8.6	73.1	3.1	20.5	57.5	287.4	--
Channel	201-28	101	VT2PRIB	68.3	47.8	96.0	8.9	72.7	3.4	20.3	56.8	307.5	--
Dairyland Seed Co.	DS-9090SSX	90	SSX	65.5	39.5	85.1	8.4	73.5	3.0	17.1	57.0	245.3	--
Dairyland Seed Co.	DS-6091	91	RR	65.5	48.7	95.9	8.8	74.0	2.8	19.5	58.7	264.4	--
Dairyland Seed Co.	DS-7294	94	3110	68.0	55.4	102.3	10.1	72.7	2.9	18.9	59.2	298.5	--
Dairyland Seed Co.	DS-9599	99	3000GT	68.3	51.4	98.0	9.3	73.1	3.0	21.0	56.8	289.1	272.8
Innotech	IC4521-3110A	95	Agrisure/Vip/3110	65.5	48.7	98.6	9.8	73.0	2.7	18.5	58.2	283.8	--
Innotech	IC4688-3120	96	Agrisure/3120	69.3	51.9	97.9	8.7	73.9	2.8	19.3	56.9	304.8	--
Integra	4652	96	VT2P	64.3	40.6	89.8	9.1	73.2	3.0	20.0	58.5	262.5	--
Latham	LH4437	94	VT2P	65.0	41.2	91.3	9.2	72.8	3.2	19.8	57.2	282.9	--
Latham	LH4645	96	VT2P	66.3	43.4	92.4	9.4	72.6	3.2	19.2	57.5	279.2	--
Latham	LH4727	97	VT2P	68.5	46.0	96.3	9.1	72.4	3.3	19.1	57.1	291.1	283.3
Latham	LH4919	99	SS	69.8	47.6	96.5	9.4	72.8	3.3	22.2	57.6	316.6	--
	MEAN			67.1	45.9	94.6	9.1	72.7	3.2	19.9	57.3	283.5	--
	C.V. (%)			1.4	4.2	2.1	1.9	0.5	5.1	4.5	1.0	5.1	--
	LSD 0.10			1.1	2.3	2.4	0.2	0.4	0.2	1.0	0.7	16.9	--
	LSD 0.05			1.3	2.7	2.8	0.2	0.5	0.2	1.3	0.8	20.2	--

Planting Date = May 5; Harvest Date = October 25; Previous Crop = Soybean

Table 1. Corn hybrid performance trial at the Oakes Irrigation Research Site in 2017.

Brand	Hybrid	RM	Hybrid Traits[1]	Days to Silk	Ear Height	Plant Height	Grain Protein	Content Starch	Content Oil	Moisture	Test Weight	Grain Yield 2017	Grain Yield 2 yr. Avg.
					inch	inch	%	%	%	%	lb/bu	bu/ac	bu/ac
Legacy Seeds	L-3416	94	VT2P RIB	64.5	39.4	91.5	8.9	72.7	3.3	19.5	57.5	266.2	249.6
Legacy Seeds	L-3517	95	VT2P RIB	67.5	44.7	93.3	9.6	71.8	3.6	20.7	58.4	298.6	--
Legacy Seeds	L-3626	96	VT2P RIB	65.8	45.8	92.0	9.2	72.4	3.4	20.2	56.6	295.1	--
Legacy Seeds	L-3715	96	GENSS RIB	66.0	45.5	91.5	8.9	73.5	2.9	19.2	58.0	266.9	259.7
Legacy Seeds	L-3712	96	VT2P RIB	67.5	43.0	91.2	9.1	72.4	3.4	19.9	58.3	275.9	--
Legacy Seeds	L-3816	99	VT2P RIB	67.5	41.0	93.3	8.6	72.4	3.4	22.1	55.7	291.2	--
Legacy Seeds	L-3916	99	GENSS RIB	68.8	50.4	100.6	9.2	72.7	3.4	20.3	58.0	287.3	--
Nutech/G2	5F-196	96	AM	67.5	47.7	97.2	8.7	72.4	3.2	19.9	55.1	296.6	282.0
Nutech/G2	5FB-5096	96	AM	66.5	42.0	88.2	9.0	73.0	3.2	20.9	56.7	256.0	--
Nutech/G2	5FN-7099		AM	70.0	44.5	93.5	9.0	72.0	3.4	22.3	52.7	289.7	--
Nutech/G2	5F-198	98	AM	67.5	45.2	97.0	8.7	72.2	3.4	18.9	53.8	306.4	291.9
Peterson Farms Seed	76S92	96	VT2P	67.3	42.8	93.8	9.1	72.4	3.6	19.1	58.4	262.7	251.0
Peterson Farms Seed	81W95	95	SmartStax	66.3	43.6	96.0	9.2	72.6	3.3	19.5	56.9	282.0	--
Peterson Farms Seed	77P94	94	VT2P	65.0	39.4	92.5	9.0	73.0	3.2	19.7	57.2	275.7	253.3
Peterson Farms Seed	78B98	98	VT2P	66.8	46.1	94.2	9.1	72.6	3.3	20.8	56.7	284.5	--
Proseed	1595	95	VT2P	65.3	39.5	88.8	9.0	73.2	3.0	19.3	58.7	261.3	--
Proseed	GX695	95	3110 VIP	68.0	55.4	101.7	10.1	72.2	3.0	19.5	59.0	289.6	--
Proseed	1598	98	VT2P	68.8	49.1	95.8	9.1	72.5	3.1	19.2	56.9	289.3	--
Proseed	16101	101	VT2P	68.0	43.3	92.8	9.1	72.0	3.6	21.9	57.3	304.3	--
	MEAN			67.1	45.9	94.6	9.1	72.7	3.2	19.9	57.3	283.5	--
	C.V. (%)			1.4	4.2	2.1	1.9	0.5	5.1	4.5	1.0	5.1	--
	LSD 0.10			1.1	2.3	2.4	0.2	0.4	0.2	1.0	0.7	16.9	--
	LSD 0.05			1.3	2.7	2.8	0.2	0.5	0.2	1.3	0.8	20.2	--

Planting Date = May 5; Harvest Date = October 25; Previous Crop = Soybean

Table 1. Corn hybrid performance trial at the Oakes Irrigation Research Site in 2017.

Brand	Hybrid	RM	Hybrid Traits[1]	Days to Silk	Ear Height	Plant Height	Grain Protein	Content Starch	Content Oil	Moisture	Test Weight	Grain Yield 2017	Grain Yield 2 yr. Avg.
					inch	inch	%	%	%	%	lb/bu	bu/ac	bu/ac
REA	4B931-RIB	93	VT2PRO	65.8	44.0	92.9	8.9	73.1	3.1	19.2	57.0	282.2	264.8
REA	4B973	97	VT2PRO	66.8	40.8	91.4	9.8	72.2	3.4	19.1	58.6	280.1	--
REA	5A982-RIB	98	SmartStax	68.5	48.8	97.0	8.7	72.4	3.6	21.3	57.7	288.3	263.0
Renk	RK433RR	92	RR2	67.8	47.7	96.3	9.1	72.6	3.4	19.3	58.0	275.5	--
Renk	RK522SSTX	94	SSTX	67.3	44.5	94.8	9.1	72.7	3.3	19.9	56.8	268.0	256.5
Renk	RK566SSTX	94	SSTX	66.5	43.8	91.7	8.9	73.4	2.9	19.5	57.7	270.0	256.0
Renk	RK568VT3P	95	VT3P	67.3	44.0	92.9	9.2	72.4	3.4	20.6	57.8	265.2	259.9
Rob-See-Co	RC4343-3110A	93	Agrisure/Vip/3220A	67.3	56.3	100.8	9.8	72.9	2.8	18.5	58.7	287.6	271.4
Rob-See-Co	RC4453-3110	94	Agrisure/Vip/3110A	67.5	54.3	100.2	10.1	72.7	2.9	18.7	59.1	287.7	--
Rob-See-Co	RC4915-3120	99	Agrisure/3120	71.0	59.2	103.8	8.9	72.1	3.6	21.8	53.0	304.7	--
	MEAN			67.1	45.9	94.6	9.1	72.7	3.2	19.9	57.3	283.5	--
	C.V. (%)			1.4	4.2	2.1	1.9	0.5	5.1	4.5	1.0	5.1	--
	LSD 0.10			1.1	2.3	2.4	0.2	0.4	0.2	1.0	0.7	16.9	--
	LSD 0.05			1.3	2.7	2.8	0.2	0.5	0.2	1.3	0.8	20.2	--

Planting Date = May 5; Harvest Date = October 25; Previous Crop = Soybean

[1] Hybrid traits as reported by seed company when hybrids submitted for evaluation.

Corn Hybrid Performance Trial – Dryland

K. Cooper, L. Besemann and H. Eslinger

A dryland corn hybrid performance trial was initiated in 2011 to provide information for corn producers in southeast and south central North Dakota. This study is conducted on Barnes-Svea soils that dominate the dryland farming in the area. This trial tested 48 hybrids.

MATERIALS AND METHODS

Soil:	Barnes-Svea; pH = 6.1; 4.1% organic matter; soil N was 20 lbs/acre; soil P was low; soil K was very high; soil S was very low.
Previous crop:	2016 - soybean.
Seedbed preparation:	Strip-till with an Orthman strip-till machine.
Planting:	Planted May 8 in 30-inch rows. Thinned to 33,200 plants/acre.
Fertilizer:	Broadcast 21 lbs N/acre, 40 lbs P_2O_5/acre, 50 lbs K_2O/acre and 15 lbs S/acre as 10-18-23-7 April 5. Stream bar 100 lbs N/acre as 28-0-0 May 23. Sidedress 92 lbs N/acre June 15 as 28-0-0.
Pest control:	Laudis (3 oz/acre) + AAtrex 9-O (0.5 lb ai/acre) + Destiny (0.05% v/v) + Interlock (4 oz/acre) May 31.
Harvest:	October 25 and October 26 with a plot combine. Harvest area was two rows 19 feet long.

RESULTS

Overall yields were lower in 2017 with a mean of 191.7 bu/ac compared to the 225.0 bu/acre mean in 2016. Yields ranged from 172.2 bu/acre to 215.6 bu/acre. The decrease in yield was primarily due to drier than normal conditions. Total rainfall recorded was 11.73 inches for the season, of which, just over 6 inches of the season total occurred after silking, from mid-August to October.

Table 2. Corn hybrid performance trial (dryland) Dickey County - Oakes Irrigation Research Site 2017.

Brand	Hybrid	RM	Hybrid Traits[1]	Days to Silk	Ear Height	Plant Height	Grain Protein	Starch Content	Oil Content	Harvest Moisture	Test Weight	Grain Yield 2017	Grain Yield 2 yr. Avg.
					inch	inch	%	%	%	%	lb/bu	bu/ac	bu/ac
Channel	193-53	93	VT2PRIB	58.8	30.7	73.7	9.7	72.9	2.9	17.9	57.6	195.6	214.7
Channel	195-18	95	VT2PRIB	60.0	31.8	74.3	9.9	72.4	3.3	19.9	58.5	183.4	205.5
Channel	197-50	97	VT2PRIB	59.8	38.1	78.8	9.2	73.2	3.0	20.2	56.3	215.6	228.1
Channel	201-28	101	VT2PRIB	62.3	36.0	78.4	9.0	73.0	3.3	20.2	56.2	212.5	--
Dairyland Seed Co.	DS-7294	94	3110	60.5	42.3	80.5	10.8	72.5	2.7	17.3	57.4	183.6	208.7
Dairyland Seed Co.	DS-9599	99	3000GT	61.8	39.2	78.8	10.2	72.6	2.9	21.6	54.5	202.0	210.0
Dairyland Seed Co.	EXP-08906	89	3010	58.5	35.6	77.0	10.8	72.7	2.4	15.5	57.0	176.1	--
Frontiersmen	094-D7VT2P	94	VT2PRO RIB	58.8	32.5	75.9	9.6	72.6	3.1	18.8	56.2	200.2	--
Frontiersmen	095-R4VT2P	95	VT2PRO RIB	61.8	33.3	74.2	9.7	72.5	3.2	21.0	56.8	189.9	--
Frontiersmen	097-R8VT2P	97	VT2PRO RIB	61.8	33.3	73.2	10.2	72.5	2.8	19.1	56.7	188.2	--
Innotech	IC4521-3110A	95	Agrisure/Vip/3110	59.0	37.7	79.9	9.8	73.2	2.7	16.6	57.2	193.4	--
Innotech	IC4730-3010	97	Agrisure/3010	61.3	38.0	78.0	10.2	72.8	3.0	21.3	56.5	181.9	197.8
Integra	4342	93	VT2P	60.5	34.2	74.9	9.5	72.5	3.4	18.2	57.1	185.6	--
Latham	LH4437	94	VT2P	58.5	32.5	73.0	9.6	72.7	3.1	18.8	56.5	194.9	215.2
Latham	LH4645	96	VT2P	59.5	32.9	73.7	9.9	72.5	3.1	17.7	56.7	189.3	--
Latham	LH4727	97	VT2P	62.8	38.3	79.5	9.4	72.6	3.2	18.6	55.8	192.8	217.9
Latham	LH4919	99	SS	63.5	38.0	77.5	9.7	73.0	3.0	21.5	56.3	198.9	--
	MEAN			60.9	35.6	75.6	9.8	72.7	3.0	19.2	56.3	191.2	--
	C.V. (%)			1.3	6.4	4.3	2.2	0.5	5.7	3.7	1.0	6.6	--
	LSD 0.10			0.9	2.6	3.8	0.2	0.4	0.2	0.8	0.6	14.9	--
	LSD 0.05			1.1	3.2	4.5	0.3	0.5	0.2	1.0	0.8	17.8	--

Planting Date = May 8; Harvest Date = October 25 & 26; Previous Crop = Soybean

Table 2. Corn hybrid performance trial (dryland) Dickey County - Oakes Irrigation Research Site 2017.

Brand	Hybrid	RM	Hybrid Traits[1]	Days to Silk	Ear Height	Plant Height	Grain Protein	Starch Content	Oil Content	Harvest Moisture	Test Weight	Grain Yield 2017	Grain Yield 2 yr. Avg.
					inch	inch	%	%	%	%	lb/bu	bu/ac	bu/ac
Legacy Seeds	L-3416	94	VT2P RIB	58.5	34.5	75.2	9.6	72.9	3.0	18.7	56.2	197.0	212.7
Legacy Seeds	L-3517	95	VT2P RIB	62.8	34.8	76.1	10.0	72.3	3.2	19.5	57.3	189.0	--
Legacy Seeds	L-3626	96	VT2P RIB	59.8	33.2	73.2	9.7	72.8	3.0	19.0	56.1	176.8	--
Legacy Seeds	L-3715	96	GENSS RIB	59.5	35.1	73.7	9.6	73.4	2.7	18.4	57.5	188.3	199.4
Legacy Seeds	L-3712	96	VT2P RIB	61.5	34.9	75.8	9.8	72.2	3.3	21.0	56.8	197.4	--
Legacy Seeds	L3816	99	VT2P RIB	60.8	32.9	74.4	9.2	72.6	3.3	23.3	55.7	213.9	--
Legacy Seeds	L3916	99	GENSS RIB	63.0	38.1	78.7	10.0	72.6	3.1	19.5	56.9	191.3	--
Mustang	3294VT2P	94	VT2P	58.8	30.1	69.8	9.6	72.9	3.0	19.3	56.4	195.7	--
Mustang	4296VT2P	96	VT2P	62.0	34.2	75.4	10.0	72.6	3.1	19.1	57.4	179.7	--
Mustang	4295CT2P	95	VT2P	61.3	33.2	73.9	9.9	72.5	3.2	19.8	57.4	192.0	--
Mustang	4297VT2P	97	VT2P	60.5	38.7	80.9	9.2	72.9	3.3	20.6	55.7	215.2	--
Nutech/G2	5F-196	96	AM	60.3	36.2	77.4	9.5	73.1	2.8	18.3	55.6	195.3	218.4
Nutech/G2	5FB-5096	96	AM	58.5	34.7	72.5	9.7	72.5	3.3	20.3	56.6	200.5	--
Nutech/G2	5F-894	94	AM	59.8	34.8	70.7	10.2	72.3	2.9	16.6	57.0	172.2	204.1
Nutech/G2	5F-198	98	AM	60.5	32.8	72.4	9.9	72.6	3.0	18.0	54.0	181.5	--
Peterson Farms Seed	76S92	96	VT2P	60.5	36.7	76.2	9.5	72.8	3.2	17.5	57.0	186.2	205.3
Peterson Farms Seed	81W95	95	SmartStax	60.0	34.5	74.8	9.9	72.6	3.1	17.3	56.6	186.9	203.9
Peterson Farms Seed	77P94	94	VT2P	58.0	31.0	73.3	9.5	73.0	3.0	19.3	56.2	199.5	221.3
Peterson Farms Seed	78B98	98	VT2P	59.5	34.5	75.9	9.4	72.4	3.3	19.9	55.8	211.0	--
	MEAN			60.9	35.6	75.6	9.8	72.7	3.0	19.2	56.3	191.2	--
	C.V. (%)			1.3	6.4	4.3	2.2	0.5	5.7	3.7	1.0	6.6	--
	LSD 0.10			0.9	2.6	3.8	0.2	0.4	0.2	0.8	0.6	14.9	--
	LSD 0.05			1.1	3.2	4.5	0.3	0.5	0.2	1.0	0.8	17.8	--

Planting Date = May 8; Harvest Date = October 25 & 26; Previous Crop = Soybean

Table 2. Corn hybrid performance trial (dryland) Dickey County - Oakes Irrigation Research Site 2017.

Brand	Hybrid	RM	Hybrid Traits[1]	Days to Silk	Ear Height	Plant Height	Grain Protein	Starch Content	Oil Content	Harvest Moisture	Test Weight	Grain Yield 2017	Grain Yield 2 yr. Avg.
					inch	inch	%	%	%	%	lb/bu	bu/ac	bu/ac
Proseed	1595	95	VT2P	58.8	31.3	70.3	9.6	73.1	2.8	17.9	58.1	206.6	--
Proseed	GX695	95	3110 VIP	60.8	41.8	81.6	10.7	72.6	2.6	17.4	57.3	185.3	--
Proseed	1598	98	VT2P	62.5	36.6	76.9	9.6	72.5	3.0	20.3	55.1	190.5	--
Proseed	16101	101	VT2P	62.3	33.2	71.9	9.7	72.6	3.2	21.8	55.9	185.6	--
Renk	RK433RR	92	RR2	60.8	36.6	76.5	9.4	73.3	2.9	16.9	56.3	194.6	--
Renk	RK568VT3P	95	VT3P	61.3	33.8	73.0	9.9	72.6	3.2	19.7	57.3	172.9	201.7
Rob-See-Co	RC4343-3110A	93	Agrisure/Vip/3220A	60.3	42.4	79.4	10.7	72.9	2.6	17.3	57.7	182.5	211.1
Rob-See-Co	RC4453-3110	94	Agrisure/Vip/3110A	60.8	39.7	78.2	11.2	72.4	2.5	17.4	56.9	178.0	--
Rob-See-Co	RC4915-3120	99	Agrisure/3120	64.3	42.5	82.0	9.9	72.5	3.2	21.0	51.9	184.0	--
Thunder Seed	6791 VT2P	91	VT2P	61.5	34.8	78.1	10.1	72.4	3.1	17.8	56.9	185.6	216.5
Thunder Seed	6798 VT2P	98	VT2P	62.0	37.2	77.8	9.5	72.5	3.2	18.6	55.9	198.3	--
Thunder Seed	4600 RR	100	RR	61.5	33.6	72.2	9.5	73.1	2.9	21.1	55.5	184.8	--
	MEAN			60.9	35.6	75.6	9.8	72.7	3.0	19.2	56.3	191.2	--
	C.V. (%)			1.3	6.4	4.3	2.2	0.5	5.7	3.7	1.0	6.6	--
	LSD 0.10			0.9	2.6	3.8	0.2	0.4	0.2	0.8	0.6	14.9	--
	LSD 0.05			1.1	3.2	4.5	0.3	0.5	0.2	1.0	0.8	17.8	--

Planting Date = May 8; Harvest Date = October 25 & 26; Previous Crop = Soybean

[1] Hybrid traits as reported by seed company when hybrids submitted for evaluation.

Onion Hybrid Performance Trial

K. Cooper, L. Besemann and H. Eslinger

Onions have done well under irrigation in North Dakota. Yellow sweet Spanish is the predominate type grown. This study tested 24 varieties: twenty-two sweet Spanish hybrids, and two red hybrids.

MATERIALS AND METHODS

Soil:	Maddock sandy loam, Embden sandy loam; pH = 7.8; 2.1% organic matter; soil N 4 lbs/acre; soil P and soil K were very high; soil S was very low.
Previous crop:	2016 - rye
Seedbed preparation:	Spring conventional tillage.
Planting:	Direct seeded onions (250,000 seeds/acre) April 29 with a Monosem precision planter. Onions were planted 2 lines per row with 2.5 inches between lines.
Plots:	Plots were three ft (two rows) wide by 25 ft long. The study had four replications.
Fertilizer:	Broadcast 21.2 lbs N/acre, 40 lbs P_2O_5/acre, 50 lbs K_2O/acre and 15 lbs S/acre as 10-18-23-7 April 4.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest control:	
Harvest:	

RESULTS

In 2017 we experienced a devastating infestation of onion maggots which effectively wiped out the entire crop at and just after emergence. The rye cover crop having been worked up and incorporated at the same time as onion maggot fly emergence would have been the likely reason for the resulting problem.

Soybean Variety Trial

K. Cooper, L. Besemann and H. Eslinger

Three soybean variety trials were conducted at the Oakes Irrigation Research Site; a Roundup Ready® trial, a Liberty Link trial and conventional soybean trial. Results for the Roundup Ready trial are listed in Table 1. Results for the Liberty Link trial are listed in Table 2. Results for the conventional trial are listed in Table 3. There were 37 varieties in the Roundup Ready trial, 9 varieties in the Liberty Link trial and 12 varieties in the conventional trial.

MATERIALS AND METHODS

Soil:	Embden loam, Spottswood loam, Lindass silty clay loam, Overly loam; pH = 6.8; 4.3% organic matter; soil N was 41 lbs/acre; soil P was high; soil K was very high; soil S was low.
Previous crop:	2016 – corn.
Seedbed preparation:	Strip-till with an Orthman strip-till machine.
Planting:	Planted May 19 in 30-inch rows.
Plots:	Plots were 25 ft long by 5 ft (2 rows) wide. The study had four replications.
Fertilizer:	Broadcast 21 lbs N/acre, 40 lbs P_2O_5/acre, 50 lbs K_2O/acre and 15 lbs S/acre as 10-18-23-7 April 4.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest control:	Weed control: Liberty Link, Roundup Ready®, and conventional soybeans received Authority (19 oz/acre) + Roundup (32 oz/acre) May 7, Select (16 oz/acre) + NIS (1 pt/100 gal) + Interlock (4 oz/acre) July 7. Disease control: Endura (5.5 oz/acre) July 20.
Harvest:	October 12 and October 13 with a plot combine.

RESULTS

Yields averaged 70.2 bu/acre in the Roundup Ready trial, 70.4 bu/acre in the Liberty Link trial and 64.6 bu/acre in the conventional trial.

Table 1. Soybean variety trial (Roundup Ready®) at the Oakes Irrigation Research Site 2017. (Page 1 of 2)

Brand	Variety	Mat Group[1]	Days to PM	Plant Lodge[2]	Seeds/ Pound	Seed Oil	Seed Protein	Test Wt	Seed Yield 2017	Seed Yield 2-yr.	Seed Yield 3-yr.
				0 to 9		%	%	lb/bu	-----bu/ac-----		
NuTech	6097R2	0.9	123.8	5.3	2138	19.1	32.3	57.4	76.5	64.4	67.8
NuTech	7109	1.0	126.0	3.8	2183	17.5	35.5	57.3	70.1	--	--
REA	RX1027	1.0	124.5	3.0	2312	17.0	36.1	57.3	73.6	--	--
REA	RX1327	1.3	126.8	5.3	2415	17.2	35.4	57.9	61.7	--	--
REA	RX1428	1.4	124.8	5.5	2395	16.6	36.0	57.1	63.0	--	--
Integra	20915N	0.9	125.0	6.5	2531	17.4	34.8	57.6	66.8	62.0	68.8
Thunder Seed	SB8710N	1.0	125.0	6.8	2469	17.1	36.2	57.4	68.2	58.7	--
Thunder Seed	SB8811N	1.1	126.5	5.3	2341	17.6	35.9	58.3	66.9	--	--
Dyna-Gro	S09RY64	0.9	124.5	4.5	2574	17.5	34.7	57.2	73.5	71.3	74.4
Dyna-Gro	S11XT78	1.1	124.5	5.3	2366	17.6	35.8	57.2	64.6	--	--
Dyna-Gro	S12RY44	1.2	124.8	5.0	2361	16.9	36.9	57.4	70.4	68.5	71.9
Dyna-Gro	S12XT07	1.2	126.0	8.0	2421	17.6	35.2	57.3	72.7	--	--
Dairyland Seed	DSR-0807/R2Y	0.8	124.8	6.0	2286	16.8	36.4	57.5	72.6	63.1	--
Dairyland Seed	DSR-0988/R2Y	0.9	125.5	5.3	2528	17.1	34.8	57.4	75.9	62.5	--
Dairyland Seed	DSR-1120/R2Y	1.1	129.8	8.8	2146	18.0	34.7	56.7	67.5	58.0	64.1
Dairyland Seed	DSR-1313/R2Y	1.3	125.8	7.3	2370	17.8	35.3	57.3	70.1	64.9	--
Dairyland Seed	DSR-1475/R2Y	1.4	129.8	7.3	2472	17.1	35.9	57.8	69.9	--	--
Proseed	XT609	0.9	124.8	5.5	2516	17.2	36.1	57.7	63.3	--	--
Proseed	XT610	1.0	125.3	5.3	2510	17.2	36.0	57.3	68.0	61.2	--
Proseed	XT612	1.2	125.8	7.0	2520	17.2	35.6	57.0	68.6	--	--
Wensman	W1086NRX	0.8	124.0	4.0	2652	16.9	36.4	56.9	68.4	--	--
Wensman	W1106NRX	1.0	124.5	3.0	2549	17.1	36.1	57.4	71.4	62.7	--
Wensman	W1121NRX	1.2	125.3	4.8	2433	17.4	35.7	57.3	68.3	--	--
Wensman	W1129NRX	1.2	127.0	5.0	2390	17.7	35.1	57.5	73.7	65.9	--
Wensman	W1140NRX	1.4	125.8	4.0	2535	17.3	35.3	57.6	76.0	--	--
	Mean		125.6	5.6	2426	17.4	35.4	57.4	70.2	--	--
	C.V (%)		1.2	30.6	2.7	1.1	0.7	1.0	7.7	--	--
	LSD 0.10		1.8	2.0	78	0.2	0.3	0.7	6.3	--	--
	LSD 0.05		2.1	2.4	93	0.3	0.3	0.8	7.6	--	--

Planting Date = May 19; Harvest Date = October 12; Previous Crop = Field Corn

Height notes were not submitted because a high wind and rain event mid-July resulted in severe lodging.

[1]Maturity group based on data provided by seed company.

[2]Plant lodge: 0 = no lodging; 9 = plants lying flat.

Table 1. Soybean variety trial (Roundup Ready®) at the Oakes Irrigation Research Site 2017. (Page 2 of 2)

Brand	Variety	Mat Group[1]	Days to PM	Plant Lodge[2]	Seeds/ Pound	Seed Oil	Seed Protein	Test Wt	Seed Yield 2017	Seed Yield 2-yr.	Seed Yield 3-yr.
				0 to 9		%	%	lb/bu	-----bu/ac-----		
Legacy Seeds	LS-0935N RR2	0.9	124.5	5.3	2321	17.2	35.2	57.9	73.6	64.8	69.6
Legacy Seeds	LS-1136N RR2	1.2	125.5	6.3	2431	17.2	35.6	57.3	67.4	--	--
Legacy Seeds	LS-1138N RR2	1.1	124.5	3.8	2360	17.5	35.9	57.7	72.6	--	--
Legacy Seeds	LS-1134N RR2X	1.1	125.5	6.8	2496	17.9	35.2	58.4	69.8	60.7	65.5
Legacy Seeds	LS-1335N RR2X	1.3	127.0	6.3	2328	17.5	35.4	57.6	73.3	64.6	71.2
Legacy Seeds	LS-1338N RR2X	1.3	127.3	5.3	2507	17.3	35.3	57.5	75.4	--	--
Peterson Farm Seed	17X09N	0.9	124.8	6.5	2514	17.2	35.7	56.8	67.3	--	--
Peterson Farm Seed	18X11N	1.1	124.3	3.8	2407	17.7	35.5	57.1	71.5	--	--
Peterson Farm Seed	18X13N	1.3	125.3	4.3	2380	18.0	35.2	57.3	72.0	--	--
Prairie Brand	PB-0777R2	0.7	124.0	4.5	2468	17.3	35.6	57.6	72.5	62.8	--
Prairie Brand	PB-0987R2	0.9	125.3	6.8	2506	17.2	34.9	57.3	70.2	61.5	--
Prairie Brand	PB-1257R2	1.2	128.3	8.3	2619	17.5	34.1	56.9	71.8	64.6	--
	Mean		125.6	5.6	2426	17.4	35.4	57.4	70.2	--	--
	C.V (%)		1.2	30.6	2.7	1.1	0.7	1.0	7.7	--	--
	LSD 0.10		1.8	2.0	78	0.2	0.3	0.7	6.3	--	--
	LSD 0.05		2.1	2.4	93	0.3	0.3	0.8	7.6	--	--

Planting Date = May 19; Harvest Date = October 12; Previous Crop = Field Corn

Height notes were not submitted because a high wind and rain event mid-July resulted in severe lodging.

[1]Maturity group based on data provided by seed company.

[2]Plant lodge: 0 = no lodging; 9 = plants lying flat.

Table 2. Soybean variety trial (Liberty Link) at the Oakes Irrigation Research Site 2017.

Brand	Variety	Mat Group[1]	Days to PM	Plant Lodge[2]	Seeds/ Pound	Seed Oil	Seed Protein	Test Wt	Seed Yield 2017	Seed Yield 2-yr.	Seed Yield 3-yr.
				0 to 9		%	%	lb/bu	-----bu/ac-----		
NuTech	2086L	0.8	124.0	2.0	2431	17.1	36.6	57.8	64.1	56.2	62.0
NuTech	3103L	1.0	125.0	7.3	2334	18.0	36.0	57.2	66.9	--	--
NuTech	3115L	1.1	125.3	8.0	2035	17.3	36.1	58.7	75.1	68.4	--
Credenz	CZ0448 LL	0.4	120.5	5.8	2190	18.5	35.3	56.6	64.6	--	--
Credenz	CZ 0525 LL	0.5	122.5	6.5	2236	17.6	36.0	58.1	69.4	63.5	67.2
Credenz	CZ 0601 LL	0.6	122.8	5.0	2152	17.0	34.4	59.7	69.8	61.3	--
Credenz	CZ 1028 LL	1.0	124.5	4.0	2205	16.6	36.6	58.2	75.0	--	--
Credenz	CZ 1201 LL	1.2	126.0	8.8	2048	17.5	35.7	58.1	71.1	63.7	--
Credenz	CZ 1332 LL	1.3	125.8	4.8	2095	16.5	36.4	58.3	77.4	--	--
	Mean		124.0	5.8	2192	17.3	35.9	58.1	70.4	--	--
	C.V (%)		0.7	29.6	2.5	0.9	0.8	2.2	7.4	--	--
	LSD 0.10		1.0	2.07	66	0.2	0.3	1.6	6.3	--	--
	LSD 0.05		1.2	2.5	80	0.2	0.4	1.9	7.6	--	--

Planting Date = May 19; Harvest Date = October 13; Previous Crop = Field Corn

Height notes were not submitted because a high wind and rain event mid-July resulted in severe lodging.

[1]Maturity group based on data provided by seed company.

[2]Plant lodge: 0 = no lodging; 9 = plants lying flat.

Table 3. Soybean variety trial (conventional varieties) at the Oakes Irrigation Research Site 2017.

Brand	Variety	Mat Group[1]	Days to PM	Plant Lodge[2]	Seeds/ Pound	Seed		Test Wt.	Seed Yield	
						Oil	Protein		2017	2-yr.
				0 to 9		%	%	lb/bu	---bu/ac---	
NDSU	Ashtabula	0.4	121.3	8.3	2580	18.6	33.2	56.9	65.2	--
NDSU	Sheyenne	0.7	123.0	3.5	2578	17.7	33.7	57.7	78.5	--
NDSU	ND Benson	0.4	121.3	5.0	2580	17.0	37.3	57.4	61.8	--
NDSU	ND Bison	0.7	122.3	1.8	2375	17.4	34.7	58.0	72.5	--
NDSU	ND Stutsman	0.7	124.0	5.0	2611	17.9	33.8	57.4	86.7	--
Richland IFC	MK0603	0.6	123.3	8.5	4503	16.3	36.3	57.6	55.6	48.4
Richland IFC	MK0508	0.8	124.0	9.0	5055	16.6	34.4	58.7	46.7	44.0
Richland IFC	MK808CN	0.8	123.5	8.3	2745	18.3	33.8	58.6	60.7	53.8
Richland IFC	MK42	0.7	123.3	8.5	2198	16.1	37.6	57.8	54.1	49.2
Richland IFC	MK1016	1.0	123.8	6.3	4679	16.0	36.9	58.4	52.0	48.7
Richland IFC	MK9101	1.0	124.5	3.3	1933	20.1	35.8	57.8	67.0	57.6
Richland IFC	MK41	1.1	125.3	3.3	2158	16.4	37.3	58.5	75.0	65.7
	Mean		123.3	5.9	3000	17.4	35.4	57.9	64.6	--
	C.V (%)		0.8	28.3	2.5	1.5	0.9	1.2	8.0	--
	LSD 0.10		1.1	2.0	90	0.3	0.4	0.8	6.2	--
	LSD 0.05		1.3	2.4	108	0.4	0.5	1.0	7.4	--

Planting Date = May 19; Harvest Date = October 12; Previous Crop = Field Corn

Height notes were not submitted because a high wind and rain event mid-July resulted in severe lodging.

[1]Maturity group based on data provided by seed company.

[2]Plant lodge: 0 = no lodging; 9 = plants lying flat.

Mosaic Soybean Study

K. Mann, K. Cooper, L. Besemann and H. Eslinger

MATERIALS AND METHODS

Soil:	Hecla sandy loam; pH = 7.1; 2.2% organic matter; soil N was 30 lbs/acre; soil P and soil K were high; soil S was medium.
Previous crop:	2016 - field pea.
Seedbed preparation:	Spring conventional tillage.
Hybrid:	Pioneer P11T22R2.
Planting:	May 15 in 30-inch rows.
Plots:	Plots were 25 ft long by 10 ft (4 rows) wide. The study had four replications.
Fertilizer:	Broadcast and incorporated treatments (see Table 1.) May 15.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest control:	Weed control: Authority (19 oz/acre) May 19. Disease control: Endura (5.5 oz/acre) July 20.
Harvest:	October 11 with a plot combine. Harvest area was the center two rows, approximately 19 feet long.

Mosaic soybean study.

Table 1. Specific details associated with treatments within the Mosaic soybean study.

Entry No.	Fertility Treatment	Formulation	Product	Formulation
				lb nutrient/acre
1	MOP	60% K2O	0-0-60	60
2	MOP	60% K2O	0-0-60	60
2	MAP	52% P2O5	11-52-0	40
3	MOP	60%K2O	0-0-60	60
3	MAP	52% P2O5	11-52-0	40
3	AS	24%	21-0-0-24S	10
4	MOP	60% K2O	0-0-60	60
4	DAP	46%P205	18-46-0	40
5	MOP	60% K2O	0-0-60	60
5	DAP	46%P205	18-46-0	40
5	AS	24.0%	21-0-0-24S	10.0
6	MOP	60% K2O	0-0-60	60
6	MES10	40%P205	12-40-0-10S	40
7	MOP	60% K2O	0-0-60	60
7	MESZ	40% P2O5	12-40-0-10S-1Zn	40
8	CHECK			

Table 2. Agronomic data for the Mosaic soybean study at the Oakes Irrigation Research Site

Treatment	Moisture	Plant Lodge[1]	Test Wt.	Yield 2017	Population
	%	0 to 9	lb/bu	bu/ac	plants/ac
MOP	12.0	3.3	57.4	76.8	87392
MOP + MAP	12.0	3.5	57.3	76.5	83308
MOP +MAP+ AS	11.8	2.8	57.8	75.5	87936
MOP + DAP	12.0	3.0	57.6	77.1	81130
MOP + DAP + AS	12.1	3.8	57.3	74.7	91475
MOP + MES10	11.9	4.5	56.9	74.4	68607
MOP + MESZ	11.8	3.8	57.3	74.6	83580
CHECK	12.0	3.8	57.5	72.3	75685
Mean	12.0	3.5	57.4	75.2	82389
C.V. (%)	1.7	30.7	0.7	5.2	14.6
LSD 0.10	0.2	1.3	0.5	4.8	14667.7
LSD 0.05	0.3	1.6	0.6	5.8	17726.8

Planting Date = May 15; Harvest Date = October 11; Previous Crop = Field Pea

[1]Plant lodge: 0 = no lodging; 9 = plants lying flat.

Strip-Till, Corn on Corn, Nitrogen Rate Study

K. Cooper, L. Besemann and H. Eslinger

Conventional-grown, continuous corn requires extensive tillage with high fuel use. Continuous corn requires about 40 lb more N/acre than corn grown on soybean ground.

The objectives of this study are to grow continuous corn in a strip-till system that eliminates full width tillage and to find efficient nitrogen rates.

MATERIALS AND METHODS

Soil:	Embden sandy loam and Hecla sandy loam; pH = 7.4; 2.9% organic matter; soil N average was 3 lbs/acre; soil P and soil K were very high; soil S was very low.
Previous crop:	2016 - field corn.
Seedbed preparation:	Strip-till May 5 with an Orthman strip-till machine.
Hybrid:	Pioneer 9929 AMXT.
Planting:	Planted May 9 in 30-inch rows @ 33,000 seeds/acre.
Plots:	Plots were 120 ft long by 20 ft (8 rows) wide. There were four replications.
Fertilizer:	All plots received (via stream-bar) 10 lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0; 15 lbs N/acre and 20 lbs S/acre as 15-0-0-20 May 22. Stream-barred 73 lbs N/acre as 28-0-0 to the 100 and 150 lb treatments and 40 lbs N/acre as 28-0-0 to the 150d and 200 lb treatments May 25. Side dress N treatments as 28-0-0 (three inches deep) June 16; the 150 lb treatment received 47 lbs N/acre, the 150d treatment received 83 lbs N/acre and the 200 lb treatment received 132 lbs N/acre.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest control:	Roundup (32 oz/acre) + AMS (10 lb/100 gal) + NIS (1 pt/100 gal) + Laudis (3 oz/acre) + Attrex 9-0 (0.5 lb ai/acre) May 26.
Remote sensing:	Opti-Sciences CCM 200 Plus chlorophyll meter.
Harvest:	October 28 with a JD 4400 combine. Harvest area was the middle four rows of each plot, about 120 feet long. Individual plot lengths were measured and were used to calculate the yield for each plot.

RESULTS

Determining nitrogen sufficiency in time is important to achieve N efficiency. Remote sensing utilized an Opti-Science CCM 200 Plus chlorophyll meter to measure N sufficiency. Increasing nitrogen rates (N) increased grain yield and chlorophyll meter readings. Remote sensing with the chlorophyll meter did well in predicting corn N status.

Table 1. Strip-till, corn on corn nitrogen rate study at the Oakes Irrigation Research Site in 2017.

Fertilizer N Rate	Grain Yield[1]	Grain Yield 2009-17	Harvest Moisture	Test Weight	Chlorophyll Meter Reading[2]	Nitrate-N		Seed Protein	Seed Starch	Seed Oil	Emerge Date	Silk Date
						Stalk	Fall Soil					
lb/ac	bu/ac	bu/ac	%	lb/bu	4-Aug	ppm	lb/ac	----------%----------				
22	93.7	87.7	18.0	56.1	14.4	36	10	6.9	73.8	3.3	25-May	24-Jul
100	199.0	174.3	19.2	55.8	45.1	18	8	7.4	73.4	3.3	25-May	22-Jul
150	232.6	196.0	19.5	55.4	52.8	211	15	8.2	72.7	3.4	25-May	23-Jul
150d	219.2	201.9	19.4	55.7	53.7	117	13	7.9	72.9	3.3	25-May	23-Jul
200	238.1	213.6	19.2	55.8	55.5	424	21	8.5	72.5	3.3	25-May	22-Jul
Mean	196.5	--	19.0	55.7	44.3	161	13	7.8	73.0	3.3	25-May	23-Jul
C.V. (%)	2.6	--	2.1	0.9	7.9	99.3	34.8	2.5	0.6	4.6	0	0
LSD 0.10	6.4	--	0.5	0.6	4.4	202	6	0.2	0.5	NS	NS	1.1
LSD 0.05	7.8	--	0.6	0.8	5.4	247	7	0.3	0.6	NS	NS	1.3

Planting Date = May 9; Harvest Date = October 28; Previous Crop = Corn

[1]Yield adjusted to 15.5% moisture.

[2]Opti-Science CCM 200.

Strip-Till, Corn on Soybean, Nitrogen Rate Study

L. Besemann and H. Eslinger

The objectives of this study were to compare corn yields of a corn/soybean rotation to those in a companion corn/corn rotation and to find differences in N response and other agronomic measurements in no-till rotations, utilizing strip-till.

MATERIALS AND METHODS

Soil:	Embden loam and Gardena sandy loam; pH = 7.4; 2.6% organic matter; Soil N average was 24 lbs/acre; soil P and soil K were very high; soil S was very low.
Previous crop:	2016 - soybean.
Seedbed preparation:	Strip-till May 5 with an Orthman strip-till machine.
Hybrid:	Pioneer 9929 AMXT.
Planting:	Planted May 9 @ 33,000 seeds per acre in 30-inch rows.
Plots:	Plots were 40 ft long by 15 ft (6 rows) wide. There were four replications.
Fertilizer:	All plots received (via stream-bar) 10 lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0; 15 lbs N/acre and 20 lbs S/acre as 15-0-0-20 May 22. Stream-barred 73 lbs N/acre as 28-0-0 to the 100 lb treatment and 40 lbs N/acre as 28-0-0 to the 100d, 150 and 200 lb treatments May 25. Sidedress N treatments as 28-0-0 (three inches deep) June 16; the 100d treatment received 35 lbs N/acre, the 150 lb treatment received 83 lbs N/acre and 200 lb treatment received 133 lbs N/acre.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest control:	Roundup (32 oz/acre) + AMS (10 lb/100gal) + NIS (1 pt/100 gal) + Laudis (3 oz/acre) + Attrex 9-0 (0.5 lb ai/acre) May 26.
Remote sensing:	Opti-Sciences CCM 200 Plus chlorophyll meter.
Harvest:	Hand harvested October 24. Harvest area was the two center rows from each plot (72 feet of total row).

RESULTS

Determining nitrogen sufficiency in time is important to achieve N efficiency. Remote sensing utilized an Opti-Science CCM 200 chlorophyll meter to determine N sufficiency. Increasing nitrogen rates (N) increased grain yield and chlorophyll meter readings. Remote sensing with the chlorophyll meter did well in predicting corn N status.

Table 1. Strip-till, corn on soybean nitrogen rate study at the Oakes Irrigation Research Site in 2017.

Fertilizer N Rate	Grain Yield[1]	Grain Yield 2009-17	Harvest Moisture	Test Weight	Chlorophyll Meter Reading[2]	Nitrate-N		Seed Protein	Seed Oil	Seed Starch	Emerge Date	Silk Date	Population
						Stalk	Fall Soil						
lb/acre	bu/ac	bu/ac	%	lb/bu	7-Aug	ppm	lbs/ac	----------%----------					plants/ac
22	175.3	135.8	19.9	55.8	41.4	12	14	3.2	7.5	73.4	25-May	21-Jul	39263
100d	253.6	198.6	19.3	56.3	45.9	59	12	3.2	8.1	72.9	25-May	20-Jul	39852
100	258.9	194.1	19.6	56.2	52.4	41	12	3.2	8.3	72.8	25-May	19-Jul	39263
150	265.5	228.2	19.8	56.3	52.5	182	18	3.1	8.4	72.9	25-May	20-Jul	39498
200	266.7	236.4	19.8	56.2	54.9	163	27	3.3	8.6	72.5	25-May	20-Jul	38969
Mean	244.0	--	19.7	56.2	49.4	91	17	3.2	8.2	72.9	25-May	20-Jul	39369
C.V. %	4.7	--	1.7	0.8	22.0	61	60	6.1	2.5	0.6	0	0	2.1
LSD 0.10	14.4	--	0.4	0.6	13.7	70	12	NS	0.26	0.6	NS	0.7	NS
LSD 0.05	17.6	--	0.5	0.7	16.7	85	15	NS	0.32	0.7	NS	0.9	NS

Planting Date = May 9; Harvest Date = November 1; Previous Crop = Soybean

[1] Yield adjusted to 15.5% moisture.

[2] Opti-Science CCM 200.

Strip-Till, Soybean on Corn Study

K. Cooper, L. Besemann and H. Eslinger

MATERIALS AND METHODS

Soil:	Embden sandy loam, Hecla sandy loam and Maddock sandy loam; pH = 7.5; 2.8% organic matter; soil N was 3 lbs/acre; soil P and soil K were very high; soil S was low.
Previous crop:	2016 - field corn.
Seedbed preparation:	Strip-till May 5 with an Orthman strip-till machine.
Hybrid:	Pioneer P11T22R2.
Planting:	May 10 @ 158,000 seeds per acre in 30-inch rows.
Fertilizer:	All plots received 12 lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0 via strip-till May 5.
Irrigation:	Overhead sprinkler irrigation as needed.
Pest control:	Authority (19 oz/acre) + Interlock (6 oz/acre) May 12, Roundup (32 oz/acre) + AMS (10 lb/100 gal) + NIS (1 pt/100 gal) + Interlock (4 oz/acre) May 31, Roundup (48 oz/acre) + AMS (10 lbs/100 gal) + NIS (1 pt/100 gal) + Interlock (4 oz/acre) July 14.
Harvest:	Harvested September 29 with an Almaco plot combine. Harvest area was four rows 97 ft long (two, two-row passes the entire length of the study).

RESULTS

The soybean yield was 60.9 bu/acre at 13.0% moisture with a test weight of 58.1 lbs/bu. The soybeans looked good overall with some white mold present in isolated spots which was expected because no fungicide was applied.

Optimum Corn Stover Removal for Biofuels and the Environment

K. Cooper, L. Besemann and H. Eslinger

The 2007 U.S. energy bill called for 36 billion gallons of ethanol to be produced by 2020. With the advent of horizontal oil well drilling and hydraulic fracking since 2007, the availability of oil has increased dramatically with a corresponding decrease in price. The use of ethanol continues to be high, but the prospects of cellulosic ethanol production in the United States does not seem to be a priority at this time. 2017 saw a production of 10 million gallons, far short of the 5.5-billion-gallon mandate. However, as this study is exploring the effects of stover removal on production and soil properties, we feel it is important to maintain this study far into the future. What effect will stover removal have on soil organic matter, soil erosion, and ultimately, sustainability of the land resource?

The objective of this study is to determine what rates of stover removal within different cropping systems are conducive to maintaining and possibly improving the productive capacity of the land.

MATERIALS AND METHODS

Rotations:	Block I: 2016 - field corn, 2015 - field corn, 2014 - field corn, 2013 - field corn, 2012 - field corn, 2011 - field corn, 2010 - field corn, 2009 field corn, 2008 - field corn, 2007 - field corn.
	Block II: 2016 - soybean, 2015 - field corn, 2014 - soybean, 2013 - field corn, 2012 - soybean, 2011 - field corn, 2010 - soybean, 2009 - field corn, 2008 - soybean, 2007 - field corn.
	Block III: 2016 - field corn, 2015 - soybean, 2014 - field corn, 2013 - soybean, 2012 - field corn, 2011 - soybean, 2010 - field corn, 2009 - soybean, 2008 - field corn, 2007 - onion.
Soil:	Embden sandy loam, Hecla sandy loam and Maddock sandy loam.
	Block I: pH = 6.7; 3.1% organic matter; soil N 5 lbs/acre; soil P was very high; soil K was medium; soil S was very low.
	Block II: pH = 6.6; 2.9% organic matter; soil N 20 lbs/acre; soil P was very high: soil K was high; soil S was very low.
	Block III: pH = 7.0; 1.9% organic matter; soil N 10 lbs/acre; soil P was very high: soil K was high; soil S was low.
Seedbed preparation:	Strip-tilled May 5 with an Orthman strip-till machine.
Hybrid: Variety:	Corn: Pioneer 9929 AMXT. Soybean: Pioneer P11T22R2.
Planting:	Block I: Corn, May 9 in 30-inch rows @ 33,000 seeds/acre.
	Block II: Corn, May 9 in 30-inch rows @ 33,000 seeds/acre.
	Block III: Soybean, May 10 in 30-inch rows @ 158,000 seeds/acre.

Fertilizer: Block I: Stream-bar 12 lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0; 15 lbs N/acre and 20 lbs S/acre as 15-0-0-20 May 22. Stream-bar 65 lbs N/acre as 28-0-0 May 23. Sidedress 134 lbs N/acre as 28-0-0 June 15.

Block II: Stream-bar 12 lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0; 15 lbs N/acre and 20 lbs S/acre as 15-0-0-20 May 22. Stream-bar 65 lbs N/acre as 28-0-0 May 23. Sidedress 134 lbs N/acre as 28-0-0 June 15.

Block III: Stream-bar 12 lbs N/acre and 40 lbs P_2O_5/acre as 10-34-0 May 22.

Irrigation: Overhead sprinkler irrigation as needed.

Pest control: Block I: Roundup (32 oz/acre) + AMS (10 lb/100 gal.) + Laudis (3 oz/acre) + Attrex 9-0 (0.5 lb ai/acre) May 26.

Block II: Roundup (32 oz/acre) + AMS (10 lb/100 gal.) + Laudis (3 oz/acre) + Attrex 9-0 (0.5 lb ai/acre) May 26.

Block III: Authority (19 oz/acre) + Interlock (6 oz/acre) May 12; Roundup (32 oz/acre) + AMS (10 lb/100 gal) + NIS (1 pt/100 gal) + Interlock (4 oz/acre) May 31 and Roundup (48 oz/acre) + NIS (1 pt/100 gal) + AMS (1 lb/10 gal) + Interlock (4 oz/acre) July 14.

Remote sensing: Remote sensing was achieved with a chlorophyll meter (Opti-Sciences CCM 200 Plus).

Harvest: Block I: Hand harvested 26 feet from rows 6 and 7 from each plot on October 30.

Block II: Hand harvested 26 feet from rows 6 and 7 from each plot on October 30.

Block III: Harvested four rows (two, two-row passes) 107 ft in length September 29 with an Almaco plot combine.

Stover removal and taking samples.

RESULTS BLOCK I (Corn/Corn) - 2017

Corn stover was removed at the 33, 67 and 100 percent removal rates in block I (corn/corn rotation). Stover removal had no significant effect on grain yield, moisture and test weight at the 95 percent confidence level. Stover removal had no effect on chlorophyll readings (Opti-Science CCM 200), and stalk nitrate-N (Table 1) at the 95 percent confidence level. Longer term data from 2009 to 2017 is presented in Table 2. The effect on revenue for the higher yield of the 100 percent removal rate compared to the 0 percent removal rate when the cost of N, P and K are accounted for is shown in Figure 1.

RESULTS BLOCK II (Corn/Soybean) - 2017

Stover removal rates of 33, 67, and 100 percent had no effect on grain yield, moisture or test weight (Table 3).

RESULTS BLOCK III (Soybean/Corn) - 2017

The soybean yield was 60.6 bu/acre at 13.0% moisture with a test weight of 58.1 lbs/bu. The soybeans had some white mold present but looked good overall considering there were no fungicide applications.

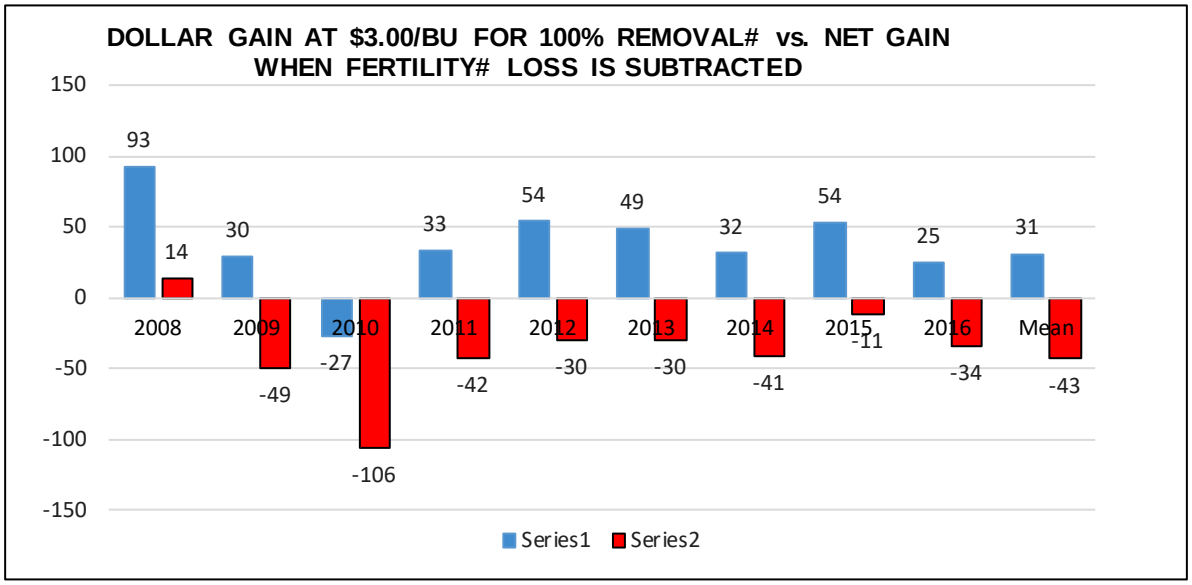

Figure 1. The net return when the fertility cost leaving the field is subtracted from the yield advantage in 100 percent removal plots compared to 0 percent removal plots for corn on corn 2008 to 2017 (Mean) at the Oakes Irrigation Research Site.

Table 1. The affect of corn stover removal from 0 to 100% on grain yield and other agronomic parameters for corn on corn plots in 2017.

Stover Removal	Grain Yield[1]	Grain Yield 2009-17	Harvest Moisture	Test Weight	Stalk DM Removal[2]	Stalk DM Removal 2008-17	Chlorophyll Meter Reading[3]	Population	Stalk Nitrate N	Fall soil Nitrate N
%	bu/ac	bu/ac	%	lb/bu	------ ton/ac ------		3-Aug	plants/ac	ppm	lb
0	261.0	220.7	17.9	56.7	0.0	0.0	59.1	34848	1299	26
33	273.4	226.8	18.1	56.5	1.0	1.9	60.6	35494	813	32
67	272.8	228.7	18.0	56.6	1.2	2.8	60.6	35171	587	16
100	269.3	229.9	17.9	56.3	1.8	4.3	60.4	35413	800	29
Mean	269.1	--	18.0	56.5	1.0	--	60.2	35231	875	26
C.V. (%)	6.3	--	2.9	0.5	10.5	--	5.5	2.4	68.0	40.9
LSD 0.10	NS	--	NS	0.4	0.1	--	NS	1094	NS	15
LSD 0.05	NS	--	NS	NS	0.2	--	NS	1350	NS	NS

Table 1. The affect of corn stover removal from 0 to 100% on grain yield and other agronomic parameters for corn on corn plots in 2017.

Stover	Seed			Emerge	Silk	Nutrients in stover[2]			Nutrient Value	
Removal	Oil	Protein	Starch	Date	Date	N	P	K	2017[2]	2008-2017
%	----------%----------					------ lb/acre ------			------ $/ac ------	
0	3.1	8.8	72.7	25-May	22-Jul	0	0	0	0	0
33	3.0	8.6	73.0	25-May	20-Jul	9	0.6	8	6	29
67	3.0	8.5	73.1	25-May	20-Jul	12	0.6	8	6	40
100	2.8	8.6	73.5	25-May	19-Jul	18	1.1	10	9	59
Mean	3.0	8.6	73.1	25-May	20-Jul	10	0.6	7	5	--
C.V. (%)	3.8	2.0	0.3	0	0	15.8	19.7	48.8	15.5	--
LSD 0.10	0.1	0.2	0.3	NS	0.9	2.0	0.1	4.2	1.0	--
LSD 0.05	0.2	0.3	0.4	NS	1.1	2.5	0.2	5.1	1.3	--

Planting Date = May 9; Harvest Date = October 30; Previous Crop = Field Corn.

Fertilizer Rate lbs/acre = 226 N, 40 P_2O_5, 20 S; Irrigation = 14.0 inches.

[1]Yield adjusted to 15.5% moisture.

[2]Corn stover removed spring of 2017 from 2016 corn crop.

[3]Opti-Science CCM 200.

Table 2. Corn on corn stover removal - NDSU Oakes Irrigation Research Site 2009-2017.

Stover Removal	Grain Yield	Harvest Moisture	Test Weight	Chlorophyll Reading	Reading NDRE[1]	Stalk Nitrate N	Grain Protein	Silk Date	Mature Date[2]
%	bu/ac	%	lb/bu			ppm	%		
0	220.7	20.2	54.8	54.5	0.3545	2183	8.7	23-Jul	29-Sep
33	226.8	19.7	55.2	55.7	0.3566	2369	8.6	21-Jul	28-Sep
67	228.7	19.7	55.0	57.3	0.3570	2314	8.6	21-Jul	27-Sep
100	229.9	19.3	55.2	56.6	0.3525	2474	8.6	20-Jul	27-Sep
Mean	226.5	19.7	55.0	56.0	0.3551	2335	8.6	21-Jul	28-Sep

[1]Data only available from 2010-2015.

[2]Maturity dates from 2009-2014

Table 3. The affect of corn stover removal from 0 to 100% on grain yield and other agronomic parameters for corn on soybean plots 2017.

Stover Removal	Grain Yield[1]	Grain Yield 2009-16	Harvest Moisture	Test Weight	Chlorophyll Meter Reading[2]	Stalk Nitrate N	Fall soil Nitrate N	Population	Seed Oil	Seed Protein	Seed Starch	Emerge Date	Silk Date
%	bu/ac	bu/ac	%	lb/bu	7-Aug	ppm	lbs	plants/ac	--------%	--------			
0	288.5	237.4	18.7	56.7	54.3	868	53	36058	3.2	8.9	72.4	25-May	19-Jul
33	305.0	233.8	18.2	56.4	58.4	697	62	35897	3.2	8.8	72.6	25-May	18-Jul
67	271.4	230.6	18.4	56.6	58.7	764	59	35332	3.1	8.7	72.8	25-May	19-Jul
100	275.3	233.7	18.2	56.5	59.6	572	59	35735	3.0	8.7	72.9	25-May	19-Jul
Mean	285.0	--	18.4	56.5	57.8	725	58	35756	3.1	8.8	72.7	25-May	19-Jul
C.V. (%)	9.1	--	1.5	0.6	4.9	40.3	58.3	3.2	3.3	1.1	0.2	0.0	0.0
LSD 0.10	NS	--	0.4	NS	3.7	NS	NS	NS	0.13	0.13	0.19	NS	NS
LSD 0.05	NS	--	0.5	NS	4.5	NS	NS	NS	0.16	0.16	0.24	NS	NS

Planting Date = May 9; Harvest Date = October 30; Previous Crop = Soybean.

Fertilizer Rate lbs/acre = 226 N, 40 P_2O_5, 20 S; Irrigation = 14.0 inches.

[1]Yield adjusted to 15.5% moisture.

[2]Opti-Science CCM 200.

Improving the management of white mold in dry edible beans

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White mold management research in dry edible beans conducted by the NDSU Carrington Research Extension Center in 2017 was focused on three areas: (1) summarizing major results from fungicide efficacy trials targeting white mold in pinto beans conducted across multiple locations in North Dakota from 2009 to 2017; (2) evaluating fungicide application timing in pinto, black and navy beans; and (3) optimizing spray nozzle selection, nozzle placement and spray droplet size for improved white mold management in pinto and kidney beans.

Methods:

Fungicide efficacy was evaluated in replicated field studies conducted in Carrington, Langdon and Oakes, ND from 2009 to 2017. Testing was conducted on 'Lariat', 'La Paz', 'Maverick', 'ND-307', 'Othello', 'Palomino', and 'Stampede' pinto beans seeded to rows 14, 16, 21, 28 or 30 inches apart. Fungicides were applied at early bloom and 10 to 14 days later using a hand-held spray boom and spray volumes of 15 to 20 gal/ac. Most applications were made with Spraying Systems TeeJet XR8001 or XR80015 flat-fan nozzles at 35 or 40 psi. Studies were conducted on sites with a prior history of white mold, and overhead irrigation was applied to facilitate disease pressure.

Fungicide application timing was evaluated in replicated field trials conducted in Carrington and Oakes in 2017. Fungicides were applied in 15 or 19 gal/ac using a hand-held boom equipped Spraying Stems XR80015 (Oakes) or DGXR80015 (Carrington) flat-fan nozzles and operated at 35 psi.

Field trials optimizing spray nozzle selection, spray droplet size, and nozzle placement were conducted in Carrington in 2017 utilizing a tractor-mounted boom equipped with a pulse-width modulation system from Capstan AG. 'Palomino' pinto beans and 'Rosie' light-red kidney beans were seeded in rows 21 inches apart in a field with a prior history of white mold, and supplemental overhead irrigation was applied to facilitate disease pressure. For applications with boom-mounted nozzles, nozzles were mounted 20 inches apart, and boom height was set relative to manufacturer's recommendations (30 inches above the canopy for 80-degree nozzles; 20 inches for 110-degree nozzles). For applications through drop nozzles, spray nozzles were mounted on the side and lower rear ports of 'Undercover 360' drop nozzles (360 Yield Center; Morton, IL); drop nozzles were mounted 21 inches apart, boom height was set such that the nozzles were 9 inches above the ground, and the tractor was driven such that drop nozzles were centered between rows of dry beans. A spray volume of 15 gal/ac and driving speed of 4.0 mph were utilized in all treatments.

Conclusions:

Fungicide efficacy: Across multi-location field trials conducted across eastern North Dakota from 2009 to 2017, the fungicides Topsin (30 fl oz/ac), ProPulse (10.3 fl oz/ac), Endura (8 oz/ac), and Omega (13.6 fl oz/ac) were most effective, conferring an average reduction in white mold of at least 35% and an average increase in yield of at least 23% relative to the non-treated control **(Table 1)**. Quash (2.5 to 4.0 oz/ac), Aproach (12 fl oz/ac), Proline (5.7 fl oz/ac), and Topsin (20 fl oz/ac) were less effective. Fungicides were tested as two sequential fungicide applications 10 to 14 days apart, but the results can also inform decision-making when a single fungicide application is made. When tested as a single versus two sequential fungicide applications, the relative efficacy of different fungicides for control of white mold in dry beans has been similar.

Fungicide application timing: In field trials conducted on pinto, black and navy beans in Carrington and Oakes in 2017, fungicides were most effective against white mold when fungicides were applied at initial pod development when pods were 0.5 to 1.0-inch-long **(Table 2)**. Optimal fungicide application

timing was similar irrespective of whether a single fungicide application was made or whether two sequential fungicide applications were made 11 to 12 days apart, and differences in canopy closure associated with narrow versus wide row spacing did not impact optimal fungicide application timing. Temperatures were high as the dry beans entered bloom, and an earlier application timing may be optimal in years when cool, wet weather occurs during bloom initiation.

Fungicide application methods: In fungicide applications with boom-mounted nozzles, the yield responses to fungicide applications were closely correlated to spray droplet size **(Table 3)**. White mold developed primarily after the second fungicide application, when cool weather created conditions highly favorable for disease. In the pinto beans, which were partially lodged when the second fungicide application was made, yields were optimized when fungicides were applied with nozzles delivering predominantly fine to medium droplets (approx. 200-250 µm diameter). In the kidney beans, which were tall and upright when the second fungicide application was made, yields were optimized when fungicides were applied with nozzles delivering medium to coarse droplets (approx. 300-350 µm diameter). The results are consistent with the expectation that medium to coarse droplets, which have increased velocity but confer reduced spray coverage, can optimize the performance of fungicides in tall, dense canopies, but additional testing is needed before rigorous recommendations can be made.

The delivery of fungicides through drop nozzles showed potential for improving fungicide performance in kidney beans **(Table 3)**. The plant architecture of the 'Rosie' kidney beans permitted two sequential applications of fungicides with drop nozzles without canopy damage, and kidney bean yields were optimized in the drop nozzle treatments. Additional gains in disease control and yield response may be possible with drop nozzles as nozzle selection and placement (side versus rear ports of the drop nozzle) are optimized. Applying fungicides concurrently through boom-mounted nozzles and drop nozzles did not improve fungicide performance, suggesting that the drop nozzles alone are able to confer satisfactory fungicide deposition. Drop nozzles may be less advantageous in pinto beans; in the field trial conducted in 2017, applications through drop nozzles could only be made at early bloom. Use of drop nozzles after canopy closure in the 'Palomino' pinto beans would have resulted in significant damage to the crop canopy.

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Table 1. Average reduction in white mold and average increase in dry bean yield (relative to the non-treated control) conferred by fungicides in replicated field trials conducted on pinto beans in Carrington, Langdon and Oakes, ND from 2009 to 2017. Results are presented for fungicides and fungicide rotation programs that were evaluated in at least five field trials. *Within-column means followed by different letters are significantly different ($P<0.05$).*

Table 1

TWO SEQUENTIAL APPLICATIONS OF THE SAME FUNGICIDE

Brand name	application rate	active ingredient(s)	number of field trials	**White mold** % reduction	**Yield** % increase
Quash 50WG	2.5 to 4.0 oz/ac	metconazole	9	10	5
Aproach 250SC	12 fl oz/ac	picoxystrobin	8	15	6
Proline 480SC	5.7 fl oz/ac	prothioconazole	14	15	8
Topsin 4.5FL	20 fl oz/ac	thiophanate-methyl	5	18	5
Topsin 4.5FL	30 fl oz/ac	thiophanate-methyl	17	38	25
ProPulse 400SC	8.6 fl oz/ac	prothioconazole + fluopyram	10	28	19
ProPulse 400SC	10.3 fl oz/ac	prothioconazole + fluopyram	12	35	25
Endura 70WG	8.0 oz/ac	boscalid	46	45	23
Omega 500F	13.6 fl oz/ac	fluazinam	8	51	32

FUNGICIDE ROTATION STRATEGIES

Products and application rates	number of field trials	**White mold** % reduction	**Yield** % increase
Topsin 30 fl oz/ac followed by Endura 8 oz/ac	11	30	23
Topsin 40 fl oz/ac followed by Endura 8 oz/ac	7	43	38
Endura 8 oz/ac followed by Topsin 40 fl oz/ac	7	38	35

Table 2. Impact of fungicide application timing on pinto, black and navy bean performance under white mold pressure; Carrington and Oakes, 2017. Testing was conducted with a single application of Topsin (30 fl oz/ac) or sequential applications of Topsin (30 fl oz/ac) followed by Endura (8 oz/ac). *Within-column means followed by different letters are significantly different (P<0.05).*

Table 2

'LA PAZ' PINTO BEANS; CARRINGTON, ND

	Fungicide application timing:		14-INCH ROW SPACING		28-INCH ROW SPACING	
	Plants with an open blossom (%)	Pod length (maximum)	**White mold** % of canopy	**Yield** lbs/ac	**White mold** % of canopy	**Yield** lbs/ac
1	Non-treated control		**86** bc*	**1297** de*	**83** cd*	**1285** c*
Treatments 2 to 5: SINGLE FUNGICIDE APPLICATION						
2	80	no pods	**88** c	**1215** e	**85** d	**1209** c
3	100	1.0 inch	**80** abc	**1739** a-d	**75** abc	**1908** ab
4	100	3.0 inch	**81** abc	**1595** b-e	**77** a-d	**1864** ab
5	100	4.0 inch	**80** abc	**1691** a-d	**75** a-d	**1671** abc
Treatments 6 to 9: TWO SEQUENTIAL FUNGICIDE APPLICATIONS 12 DAYS APART						
6	80	no pods	**79** abc	**1686** a-e	**75** abc	**1719** abc
7	100	1.0 inch	**74** a	**2158** a	**70** a	**2163** a
8	100	3.0 inch	**74** a	**1997** ab	**70** ab	**1974** ab
9	100	4.0 inch	**78** ab	**1825** abc	**77** a-d	**1729** abc
		CV:	9.8	24.2	11.5	25.9

'ECLIPSE' BLACK BEANS; OAKES, ND

	Fungicide application timing:		14-INCH ROW SPACING			
	Plants with an open blossom (%)	Pod length (maximum)	**White mold** % incidence	**White mold** % of canopy	**Yield** lbs/ac	**Sclerotia** % by weight
1	Non-treated control		**91** e	**74** f	**2897** d*	**1.2** d
Treatments 2 to 5: SINGLE FUNGICIDE APPLICATION						
2	68	no pods	**84** e	**64** ef	**3197** cd	**1.0** d
3	100	no pods	**79** de	**56** de	**3509** bc	**0.8** cd
4	100	0.5 inch	**72** cd	**49** cd	**3924** ab	**0.7** bc
5	100	1.5 inch	**63** bc	**42** bc	**4122** a	**0.5** ab
Treatments 6 to 9: TWO SEQUENTIAL FUNGICIDE APPLICATIONS 11-12 DAYS APART						
6	68	no pods	**67** bc	**42** bc	**3943** ab	**0.5** ab
7	100	no pods	**62** bc	**39** abc	**4302** a	**0.5** ab
8	100	0.5 inch	**47** a	**28** a	**4441** a	**0.3** a
9	100	1.5 inch	**56** ab	**36** ab	**4184** a	**0.4** ab
		CV:	15.4	21.1	11.8	34.1

Table 2 (continued)

'ECLIPSE' BLACK BEANS; CARRINGTON, ND

	Fungicide application timing:		14-INCH ROW SPACING		28-INCH ROW SPACING	
	Plants with an open blossom (%)	Pod length (maximum)	**White mold** % of canopy	**Yield** lbs/ac	**White mold** % of canopy	**Yield** lbs/ac
1	Non-treated control		**48** c*	**2219** b*	**61** b*	**1763** b*
Treatments 2 to 5: SINGLE FUNGICIDE APPLICATION						
2	15	no pods	**41** bc	**2363** ab	**60** b	**1918** ab
3	50	no pods	**33** abc	**2480** ab	**46** ab	**2225** ab
4	75	0.5 inch	**37** bc	**2292** ab	**55** ab	**1894** ab
5	85	1.5 inch	**32** abc	**2475** ab	**53** ab	**2004** ab
Treatments 6 to 8: TWO SEQUENTIAL FUNGICIDE APPLICATIONS 12 DAYS APART						
6	50	no pods	**20** a	**2748** ab	**39** a	**2067** ab
7	75	0.5 inch	**28** ab	**2699** ab	**38** a	**2284** a
8	85	1.5 inch	**26** ab	**2779** a	**41** a	**2216** ab
		CV:	26.3	13.0	19.3	14.5

'AVALANCHE' NAVY BEANS; CARRINGTON, ND

	Fungicide application timing:		14-INCH ROW SPACING		28-INCH ROW SPACING	
	Plants with an open blossom (%)	Pod length (maximum)	**White mold** % of canopy	**Yield** lbs/ac	**White mold** % of canopy	**Yield** lbs/ac
1	Non-treated control		**50** b*	**2183** b*	**55** ab*	**1965** d*
Treatments 2 to 5: SINGLE FUNGICIDE APPLICATION						
2	15	no pods	**50** b	**2383** ab	**58** ab	**2010** cd
3	50	no pods	**45** ab	**2375** ab	**61** b	**1987** cd
4	75	0.5 inch	**42** ab	**2341** ab	**55** ab	**2129** bcd
5	85	1.5 inch	**41** ab	**2390** ab	**56** ab	**2099** bcd
Treatments 6 to 8: TWO SEQUENTIAL FUNGICIDE APPLICATIONS 12 DAYS APART						
6	50	no pods	**36** ab	**2852** a	**45** ab	**2326** abc
7	75	0.5 inch	**33** ab	**2913** a	**48** ab	**2522** a
8	85	1.5 inch	**29** a	**2668** ab	**41** a	**2444** ab
		CV:	25.2	12.3	18.4	8.7

Table 3. Impact of nozzle type, nozzle placement, application pressure and spray droplet size on white mold control and dry bean yield in pinto and kidney beans; Carrington, 2017. Testing was conducted with a single application of Topsin (30 fl oz/ac) or sequential applications of Topsin (30 fl oz/ac) followed by Endura (8 oz/ac). In treatments 4 and 12, half of the spray volume was delivered through boom-mounted XR8004 nozzles (40 psi), and half was delivered through drop nozzles equipped with XR11001and TX-VK6 nozzles (side and rear ports). *Within-column means followed by different letters are significantly different (P<0.05)*

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Table 3

'ROSIE' LIGHT-RED KIDNEY BEANS; CARRINGTON, ND

	Nozzle placement	Spray nozzles		Droplet size	White mold % of canopy	Yield lbs/ac
1	Non-treated control				**51** b*	**2419** d
Treatments 2 to 4:	SINGLE FUNGICIDE APPLICATION (July 10 at early bloom)					
2	boom	XR8004	40 psi	medium-fine	**41** ab	**2637** cd
3	drop nozzle	XR11001 + TX-VK6	40 psi	fine	**39** ab	**2765** bcd
4	boom-moounted nozzles + drop nozzle				**36** ab	**2642** bcd
Treatments 5 to 12:	TWO SEQUENTIAL FUNGICIDE APPLICATIONS (July 10 and 20)					
5	boom	XR8004	60 psi	fine	**31** a	**2860** a-d
6	boom	XR8004	40 psi	medium-fine	**29** a	**2885** abc
7	boom	XR8006	40 psi	medium-coarse	**43** ab	**2825** a-d
8	boom	XR8010	40 psi	coarse	**29** a	**3091** abc
9	boom	TJ60-8005	40 psi	medium-fine	**34** ab	**2775** a-d
10	boom	AIXR110015	60 psi	medium-coarse	**26** a	**2933** abc
11	drop nozzle	XR11001 + TX-VK6	40 psi	fine	**27** a	**3233** a
12	boom-moounted nozzles + drop nozzle				**24** a	**3100** ab
			CV:		29.1	8.3

Impact of irrigation management and fungicide timing on Sclerotinia stem rot in black beans

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Oakes, ND (2017)

Agronomic details:	
Tillage:	Apr 30 - disk (Wishek), May 2 - soil finisher, May 11 - rototill (breakup clods from the rye cover crop)
Soil type:	Spottswood loam, Lindaas silty clay loam (small area in the NE corner), Ovely loam, Gardena loam-clayey substratum, Gardena loam-sandy substratum
Previous crop:	Soybeans and field peas (2016); spring wheat (2015)
Soil test results:	N = 32 lbs, P (ppm) = 20, K (ppm) = 202, S = 6 lbs, Zn (ppm) 5.63, OM = 3.8, pH = 6.7
Supplemental fertilization:	April 6; spread 218 lb/acre; N=21.2 lbs, P=40 lbs, K=50 lbs, S=15 lbs/acre as 10-18-23-7
Herbicide applications:	Pre-plant incorporated: None Pre-emergence: April 24, Roundup 32 oz/acre (to kill the rye cover crop); May 19, Spartan/Authority = 19 oz/acre Post-emergence: None
Experimental design:	
Experimental design:	completely randomized block design with a split-plot arrangement and five replicates
Seeded plot size:	25 feet long x 5 feet (center-to-center)
Harvested plot size:	approx. 19 feet x 5 feet (center-to-center)
Row spacing:	14-inch row spacing; 4 rows per plot
	Guard plots were established on the edges of the trial, and non-harvested buffer plots were established between treatment plots within the trial.
Planting details:	
Variety:	'Eclipse', a black bean
Planting date:	June 9, 2017
Seeding rate:	100,000 pure live seeds/ac
Disease establishment:	
Sclerotinia (white mold):	This research trial was planted on land with a prior history of white mold.
Irrigation management - dates and quantities:	
Irrigation treatment 1: 1.00" when irrigation needed	May 11 = 0.50", May 12 = 0.75"; Jun = 3 & 8 = 0.50" each, Jun 21 = 0.60"; Jul = 5, 7, 10, 13 and 16 = 0.75" each; Jul 24 & 30 = 1.00" each; Aug 5, 10 & 26 = 1.00" each.

Irrigation treatment 2: two sequential applications of 0.5" when irrigation needed	May 11 = 0.50", May 12 = 0.75"; Jun = 3 & 8 = 0.50" each, Jun 21 = 0.60";Jul = 5, 7, 10, 13 and 16 = 0.75" each; Jul 24, 25 & 30, 31 = 0.50" each; Aug 5, 10, 11 & 26, 27 = 0.50" each.
Irrigation treatment 3: two sequential applications of 0.5" until first appearance of disease	May 11 = 0.50", May 12 = 0.75"; Jun = 3 & 8 = 0.50" each, Jun 21 = 0.60"; Jul = 5, 7, 10, 13 and 16 = 0.75" each; Jul 24, 25 & 30, 31 = 0.50" each; Aug 5, 10 & 11 = 0.50" each.
Fungicide applications	
Fungicide application A:	Topsin 4.5FL applied at 30 fl oz/ac on July 22 at 8:15-8:50 am; 67.5% of plants with at least one open blossom, no pods yet, 75-95% canopy closure; no white mold present. Air temperature = 67˚F, relative humidity = 95-96%, wind speed = 2-5 mph.
Fungicide application B:	Topsin 4.5FL applied at 30 fl oz/ac on July 24 at 11:15 am - 12:00 noon; 100% of plants with at least one open blossom, no pods yet, 75-100% canopy closure; no white mold present. Air temperature = 72-75˚F, relative humidity = 66-68%, wind speed = 9-14 mph.
Fungicide application C:	Topsin 4.5FL applied at 30 fl oz/ac on July 26 at 10:40-11:30 am; full bloom, 30% of plants with most pods 0.5 inches long, 85-100% canopy closure; no white mold present. Air temperature = 76-77˚F, relative humidity = 55-60%, wind speed = 5-15 mph.
Fungicide application D:	Topsin 4.5FL applied at 30 fl oz/ac on July 28 at 8:55-9:40 am; full bloom, pods 100% (½ to 1" = 10/10; 4-5/10 had at least one pod 1-2"); 100% canopy closure (except where there were gaps in the stand); no white mold present. Air temperature = 69-72˚F, relative humidity = 59-74%, wind speed = 2-4 mph.
Fungicide application E:	Endura 70WG applied at 8 oz/ac on Aug 3 at 1:30-2:10 pm, full bloom (new flowers upper canopy, older flowers senescing), pods ½ to 4" =10/10 plants, 10/10 have multiple pods 3-4" long; R5; 100% canopy closure; no white mold present; Air temperature = 67°F, relative humidity = 53-58%, wind speed = 9-14 mph.
Fungicide application F:	Endura 70WG applied at 8 oz/ac on Aug 5 at 10:00-10:40 am, full bloom (new flowers upper canopy, older flowers senescing), pods ½ to 4" =10/10 plants, 10/10 have multiple pods 3-4" long; R5; 100% canopy closure; no white mold present; Air temperature = 68-75°F, relative humidity = 53-58%, wind speed = 1-6 mph.
Fungicide application G:	Endura 70WG applied at 8 oz/ac on Aug 7 at 1:45-2:05 pm, full bloom (new flowers upper canopy, older flowers senescing), pods ½ to 4" =10/10 plants, 10/10 have multiple pods 3-4" long; R5-R6; 100% canopy closure; no white mold present; Air temperature = 77-78°F, relative humidity = 40%, wind speed = 4-9 mph.
Fungicide application H:	Endura 70WG applied at 8 oz/ac on Aug 8 at 1:55-2:25 pm, full bloom (new flowers upper canopy, older flowers senescing), pods ½ to 4" =10/10 plants, 10/10 have multiple pods 3-4" long; R5-R6; 100% canopy closure; no white mold present; Air temperature = 79°F, relative humidity = 41-45%, wind speed = 6-13 mph.
Fungicide application details:	Fungicides were applied with a 60-inch hand boom equipped with four equally spaced Spraying Systems XR80015 nozzles at a spray volume of 19 gal water/A operated at 35 psi.
In-season data collection:	
Sclerotinia disease assessments:	Assessed by invidually assessing every plant in each plot (replicates 1 and 2) or every plant in the middle two rows of each plot (replicates 3 to 5) for the percent of the plant exhibiting white mold symptoms. Sclerotinia incidence = percent of plants exhibiting white mold symptoms; Sclerotinia severity = average percent of plant tissue exhibiting white mold symptoms among plants with the disease; Sclerotinia severity index = percent of canopy exhibiting white mold symptoms. Evaluated September 11-12 at the late R7 to R8 growth stage when seeds were fully developed and the foliage was yellowing.
Harvest and seed yield and quality assessment:	
Desiccation:	The pinto beans were direct-harvested but were not desiccated prior to harvest. To facilitate uniform dry-down across all plants, plants were manually pulled (to simulate knifing) concurrent with disease assessments on Sept. 11-12.
Harvest date:	September 18, 2017

Evaluation of seed treatment with streptomycin for management of seed-borne bacterial blight in field peas

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Research objective:
Evaluate the efficacy, yield response, and economic returns to streptomycin seed treatment in field peas with low, intermediate, and elevated seed-borne *Pseudomonas syringae* pv. *pisi.*

Conclusions:
Across field trials conducted in Carrington and Oakes in 2016 and 2017 under significant bacterial blight foliar disease pressure (**Figure 1**):

- Seed treatment with the antibiotic streptomycin (applied as the commercial product AS-50 at 0.91 oz/cwt) was consistently associated with reduced foliar disease and increased yield when applied to seed testing positive for seed-borne *Psuedomonas syringae*.
- The average yield gains observed (1 bu/ac in seed lots with very low levels of seed-borne *P. syringae*) and 3 bu/ac in seed lots with moderate levels of seed-borne *P. syringae* suggest that seed treatment with AS-50 will likely be profitable when applied to seed lots with moderate levels of seed-borne *P. syringae.*
- Seed treatment with the antibiotic streptomycin (applied as the commercial product AS-50 at 0.91 oz/cwt) was not consistently associated with reduced foliar disease or increased yield when applied to seed testing negative for seed-borne *Psuedomonas syringae*.
- Seed treatment with streptomycin will need to supplemented with other in-season management practices to achieve satisfactory control of bacterial blight after severe weather events such as hail. Seed-borne *P. syringae* is not the only contributor to bacterial blight, and even when disease-free seed was utilized, unacceptably high levels of disease developed after the imposition of conditions simulating hail damage.

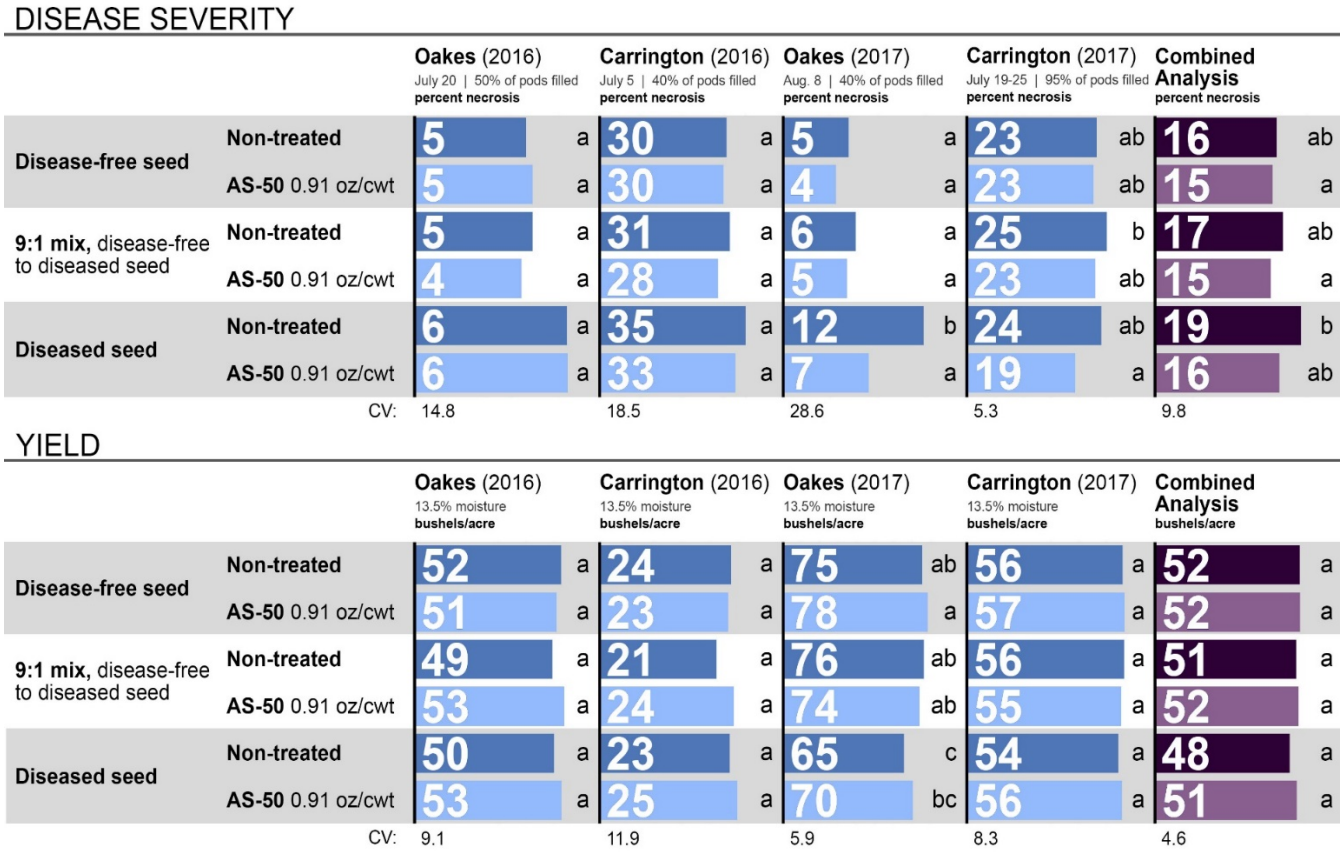

Figure 1. Response to seed treatment with the antibiotic streptomycin in field peas grown from seed testing negative or testing positive for seed-borne *Pseudomonas syringae*, the pathogen causing bacterial blight; Carrington and Oakes, ND (2016, 2017).

Methods

Carrington, ND (2017)

Location of trial: NDSU Carrington Research Extension Center, approximately 3.5 miles north of Carrington, ND.

GPS coordinates: 47°30'30.4"N 99°08'06.3"W (easternmost rep), 47°30'30.4"N 99°08'14.4"W (westernmost rep)

Agronomics

Soil type: Heimdal-Emrick loam

Previous crop: wheat

Tillage: Cultivated on April 20 and 22, 2016

Soil fertility: Nitrogen = 20 lb/ac in the top 6 inches and 12 lb/ac 6 to 24 inches below surface; phosphorous = 20 ppm; potassium = 277 ppm; sulfur = 36 lb/ac in the top 6 inches and 84 lb/ac at 6 to 24 inches below the surface; zinc = 0.82 ppm; copper = 0.74 ppm; organic matter = 2.9%; soluble salts = 0.28 mmho/cm in the first 6 inches and 0.27 mmho/cm at 6 to 24 inches below the surface; soil pH = 7.8 in the first 6 inches and 8.1 at 6 to 24 inches below the surface.

Rhizobium inoculant: Primo GX2 granulated peat inoculant plus biological growth promoter (Azospirillum brasilense 1x105 CFU/g + Rhizobium leguminosarum v. viceae 1x108 CFU/g);

Verdesian Life Sciences, U.S., LLC; Cary, NC. Applied in-furrow at 10.2 lbs/ac (above the manufacturer's recommended rate of 7.5 lbs/ac).
Maintenance herbicide applications: Maintenance herbicide applications: Pre-plant incorporated: 2 pt/ac Sonalan HFP (ethalfluralin, 3 lbs ai/gal; Dow AgroSciences), applied April 21 and incorporated April 21 and 22. Pre-emergence: 4 fl oz/ac Sulfentrazone 4SC (sulfentrazone, 4 lbs ai/gal; Willowood USA, Roseburg, OR) applied shortly after planting on April 22. Post-emergence: 5 fl oz/ac Shadow 3EC (clethodim, 3 lbs ai/gal; Arysta LifeScience North America, LLC; Cary, NC) + 1.25 pt/ac MSO applied on June 6.
Maintenance fungicide applications: None applied.
Experimental design randomized complete block with six replicates
Seeded plot size: 20 feet (center-to-center) x 50 feet long, consisting of four passes of the planter (each 5 ft wide)
Harvested plot size: 10 feet (center-to-center) x approx. 40 feet long, consisting of two passes of the plot combine (each 5 ft wide)
Row spacing: 7 inches (7 rows per 5-foot-wide planter pass)
Treatment plots were separated by a 20-foot buffer of soybeans (north-south) or a 50-foot buffer of wheat (east-west)
Variety: DS Admiral' yellow pea
Seeding rate: 330,000 pure live seeds/ac.
Planting date: April 22, 2017
Soil temperature: (at planting) 49-53°F

Treatments

Streptomycin seed treatment: In order to achieve the target application rate of 0.91 oz of AS-50 (65.8% streptomycin sulfate by weight; NuFarm Americas, AGT Division, Alsip, IL) per 100 lbs of seed, 31.29 grams AS-50 were mixed with 275 ml of water. The resulting solution was applied to seed at an application rate of 5 ml per 1,000 grams of seed. Seed treatment was conducted with a Hege seed treatment machine.
Kenmare seed lot: Kenmare seed lot: 'DS Admiral' peas produced in Kenmare, ND in 2016; bacterial blight did not develop in-season at significant levels, and seed tested negative for seed-borne Pseudomonas syringae pv. pisi.
Oakes seed lot: Oakes seed lot: 'DS Admiral' peas harvested in 2016 in a bacterial blight management study conducted at the NDSU Robert Titus Research Farm in Oakes; moderate levels of bacterial blight developed during the growing season, and seed tested positive for seed-borne Pseudomonas syringae pv. pisi.
9:1 ratio of Kenmare and Oakes seed lots: A mixture of seed from the Kenmare (seed tested negative for seed-borne P. syringae) and Oakes (seed tested positive for seed-borne P. syringae) seed lots mixed in a 9:1 ratio (Kenmare: Oakes) on a pure-live-seeds basis.

Imposition of environmental conditions favorable for bacterial blight

Sandblasting: Application #1 June 12, 2017 at 2:45-5:15 pm when peas had 14-15 nodes, with 1 inch of irrigation applied through micro-sprinklers over a 15-hour period from 5:20 pm on June 12 through 8:20 am on June 13. Application #2 June 20, 2017 at 9:00 am to 12:05 pm when 5 to 10% of plants had at least one open blossom (bloom initiation) and with 1.5 inches of irrigation applied through micro-sprinklers over a 24-hour period from 1:40 pm on June 20 through 1:40 pm on June 21.
Sandblasting methods: Standard play sand or paver leveling sand was utilized. To remove large particles, sand was passed through a #12 mesh sieve with 1.68 x 1.68 mm square openings (W.S. Tyler Company; Menton, OH). The sieved sand was applied to the peas with a 30-pound siphon feed sand

blaster (Maxus; Harrison, OH) operated at 90 psi. Sand was applied at a height of 22 inches above the canopy with sand applied to each half of each plot (a 2.5-foot width) with a back-and-forth motion perpendicular to the plot such that the entire plot length (25 feet) was covered in 15 seconds.

In-season notes:

Phytotoxicity: percent crop injury relative to non-treated seed; a rating of zero denotes no phytotoxicity. Assessed June 15 when peas had 7 to 8 nodes.

Plant population: assessed by counting all plants within two 3.05-meter lengths of row in each plot. Evaluated on May 22 when peas had 4 to 5 nodes.

Bacterial blight severity: assessed by (1) evaluating canopy necrosis in each fourth of each plot on July 19-25 at late pod-fill and (2) evaluating the incidence of pods exhibiting lesions characteristic of bacterial blight by assessing all pods on each of six plants per plot (two plants in each third of each plot) on July 21 and 24 at late pod-fill (95% of pods were fully filled on July 24).

Harvest:

Harvest date: Aug. 14

Harvested plot length: To facilitate accurate yield assessment, plot lengths were measured at harvest.

Seed yield and quality evaluations: 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 quality results were adjusted from the observed moisture level of the grain to a standard 13.5% moisture level.

Statistical analysis:

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. Data that did not meet model assumptions were subjected to a systematic natural-log transformation, and analysis was conducted on the transformed data. For ease of interpretation, treatment means in the summary table were calculated from the untransformed data; to identify where a natural-log transformation was applied, the symbol ‡ was placed at the top of that column of results in the summary table. 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).

Oakes, ND (2017)

Location of trial: NDSU Robert Titus Research Farm, approximately 3 miles south of Oakes, ND.

GPS coordinates: 46°04'03.8"N 98°05'35.1"W

Agronomics

Soil type: Maddock sandy loam

Tillage: convention tillage (disked, multiweed, and rototilled)

Previous crop: dry edible beans followed by winter rye

Rhizobium inoculant: Primo GX2 granulated peat inoculant plus biological growth promoter (Azospirillum brasilense 1x105 CFU/g + Rhizobium leguminosarum v. viceae 1x108 CFU/g; Verdesian Life Sciences, U.S., LLC; Cary, NC) was applied in-furrow with the seed at an application rate of 12.5 g per 125 ft2 plot (9.6 lbs/ac; 30% above the manufacturer's recommended rate of 7.5 lbs/ac).

Maintenance herbicide applications: Spartan/Authority 19oz/ac, applied pre-emergence after the first time that this trial was planted (in early May); Basagran 16 oz/ac + Raptor 3oz/ac + NIS 1qt/100gal applied post-emergence after the second time that this trial was planted (in late June)
Maintenance fungicide applications: To prevent the development of Ascochyta blight, the foliar fungicide Proline was applied during bloom and pod-fill at 5.7 fl oz/ac on July 21, July 26, Aug. 6, and Aug. 11
Experimental design: randomized complete block with six replicates
Seeded plot size: 30 feet (center-to-center) x 25 feet long (3 replicates) or 20 ft x 50 ft (3 replicates)
Harvested plot size: 20 feet (center-to-center) x approx. 20 feet long (3 replicates) or 20 ft x approx. 40 ft (3 replicates)
Row spacing: each plot consisted of multiple passes of the planter, with each planter pass consisting of an 18-inch tire track alley and seven rows, each 7 inches apart
Treatment plots were separated by a 20- or 25-foot buffer of soybeans in all directions.
Variety: 'DS Admiral' yellow pea
Seeding rate: 330,000 pure live seeds/ac.
Planting date: June 9. Due to severe losses caused by seed-corn maggot, the initial planting (on May 5) was terminated and the trial was replanted on June 9.
Soil temperature at planting: 75-77°F; low and high turf soil temperatures in the 24-hour period after planting = 69°F and 79°F

Treatments

Streptomycin seed treatment: In order to achieve the target application rate of 0.91 oz of AS-50 (65.8% streptomycin sulfate by weight; NuFarm Americas, AGT Division, Alsip, IL) per 100 lbs of seed, 28.44 grams AS-50 were mixed with 0.25 liter of water. The resulting solution was applied to seed at an application rate of 5 ml per 1,000 grams of seed. Seed treatment was conducted with a Hege seed treatment machine.
Disease-free seed: 'DS Admiral' peas harvested in 2016 in Kenmare, ND; bacterial blight did not develop in-season at significant levels, and seed tested negative for seed-borne Pseudomonas syringae pv. pisi.
Diseased seed: 'DS Admiral' peas harvested in 2016 in Oakes, ND; bacterial blight occurred at moderate levels (5% of canopy exhibiting bacterial blight when 50% of pods were fully filled), and seed tested positive for seed-borne Pseudomonas syringae pv. pisi.
9:1 ratio of disease-free and diseased seed lots: A mixture of seed from the seed lots mixed in a 9:1 ratio (disease-free: diseased) on a pure-live-seeds basis.

Imposition of environmental conditions favorable for bacterial blight

Sandblasting methods: Standard play sand or paver leveling sand was utilized. To remove large particles, sand was passed through a #12 mesh sieve with 1.68 x 1.68 mm square openings (W.S. Tyler Company; Menton, OH). The sieved sand was applied to the peas with a 30-pound siphon feed sand blaster (Maxus; Harrison, OH) operated at 90 psi. Sand was applied at a height of 22 inches above the canopy with sand applied to each half of each plot (a 2.5-foot width) with a back-and-forth motion perpendicular to the plot such that the entire plot length (25 feet) was covered in 15 seconds.
Sandblasting - application #1. Thursday, July 6. Field peas at 9 nodes.
Sandblasting - application #2. Thursday, July 13. Field peas at 11-12 nodes.
Sandblasting - application #3. Thursday, July 20. Field peas at 17 to 18 nodes; full bloom, no pods
Irrigation: Overhead irrigation was applied within 24 hours of the conclusion of sandblasting, with 1 inch of irrigation applied through an overhead linear overhead irrigation system.

In-season notes:

Phytotoxicity: percent crop injury relative to non-treated seed; a rating of zero denotes no phytotoxicity. Assessed June 30 when peas had 2 to 3 nodes.
Plant population: assessed by counting all plants within two 3.05-meter lengths of row in each plot. Assessed June 30 when peas had 2 to 3 nodes.
Bacterial blight severity: assessed by assessing percent canopy necrosis in each third of each plot on Aug. 8 at mid-pod fill (40% of pods fully filled).

Harvest:

Harvest date: Sept. 11
Harvested plot length: To facilitate accurate yield assessment, plot lengths were measured at harvest.
Seed yield and quality evaluations: 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 quality results were adjusted from the observed moisture level of the grain to a standard 13.5% moisture level.

Statistical analysis:

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. Data that did not meet model assumptions were subjected to a systematic natural-log transformation, and analysis was conducted on the transformed data. For ease of interpretation, treatment means in the summary table were calculated from the untransformed data; to identify where a natural-log transformation was applied, the symbol ‡ was placed at the top of that column of results in the summary table. 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).

Table 1. Response to seed treatment with the antibiotic streptomycin in field peas grown from seed testing negative or testing positive for seed-borne *Pseudomonas syringae*, the pathogen causing bacterial blight; Carrington, ND (2017).

Treatments

1	Non-treated	Kenmare seed lot (negative, seed-borne *P. syringae*)
2	AS-50 0.91 oz/cwt	Kenmare seed lot (negative, seed-borne *P. syringae*)
3	Non-treated	9:1 ratio (pure live seeds), Kenmare:Oakes seed lots
4	AS-50 0.91 oz/cwt	9:1 ratio (pure live seeds), Kenmare:Oakes seed lots
5	Non-treated	Oakes seed lot (positive for seed-borne *P. syringae*)
6	AS-50 0.91 oz/cwt	Oakes seed lot (positive for seed-borne *P. syringae*)

Results - stand establishment and disease:

	------ May 22 | 4-5 nodes ------			BACTERIAL BLIGHT SEVERITY	
	Plant population	**Vigor**	**Phyto-toxicity**	**July 21, 24** | late pod-fill (95% of pods fully filled)	**July 19-25** | late pod-fill (95% of pods fully filled)
	plants/ac	%	%	%	%
1	**290296** a*	**82** a*	**0**	**43** a*	**23** ab*‡
2	**301964** a	**82** a	**0**	**45** a	**23** ab
3	**295430** a	**81** a	**0**	**48** a	**25** b
4	**306009** a	**78** ab	**0**	**44** a	**23** ab
5	**275984** a	**72** b	**0**	**50** a	**24** ab
6	**270383** a	**75** ab	**0**	**48** a	**19** a
F:	2.51	5.50		1.07	2.67
P>F:	0.0570	0.0015		0.4031	0.0456
CV:	7.6	5.4		14.1	5.3

Results - seed yield and quality:

	13.5% moisture			**Seed size** (seed diameter)		
	Yield	**Test Weight**	**Seed weight**	> 7.15 mm	> 6.75 mm	< 6.35 mm
	bu/ac	lbs/bu	seeds/lb	% by weight		
1	**56** a*	**62** a*	**2104** a*	**18** a*	**58** a*	**16** a*
2	**57** a	**62** a	**2129** a	**18** a	**56** a	**17** a
3	**56** a	**62** a	**2034** a	**20** a	**63** a	**11** a
4	**55** a	**62** a	**2136** a	**17** a	**56** a	**16** a
5	**54** a	**62** a	**2108** a	**17** a	**58** a	**15** a
6	**56** a	**62** a	**2108** a	**17** a	**59** a	**14** a
F:	0.18	0.76	1.26	1.13	0.90	1.13
P>F:	0.9662	0.5856	0.3103	0.3711	0.4991	0.3688
CV:	8.3	0.5	3.8	14.6	10.9	31.3

* **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.

Table 2. Response to seed treatment with the antibiotic streptomycin in field peas grown from seed testing negative or testing positive for seed-borne *Pseudomonas syringae*, the pathogen causing bacterial blight; Oakes, ND (2017).

Treatments:

1	3 fl oz/cwt Imidacloprid 4ST	Kenmare seed lot (negative, seed-borne *P. syringae*)
2	3 fl oz/cwt Imidacloprid 4ST + AS-50 0.91 oz/cwt	Kenmare seed lot (negative, seed-borne *P. syringae*)
3	3 fl oz/cwt Imidacloprid 4ST	9:1 ratio (pure live seeds), Kenmare:Oakes seed lots
4	3 fl oz/cwt Imidacloprid 4ST + AS-50 0.91 oz/cwt	9:1 ratio (pure live seeds), Kenmare:Oakes seed lots
5	3 fl oz/cwt Imidacloprid 4ST	Oakes seed lot (positive for seed-borne *P. syringae*)
6	3 fl oz/cwt Imidacloprid 4ST + AS-50 0.91 oz/cwt	Oakes seed lot (positive for seed-borne *P. syringae*)

Results:

	Bacterial blight severity	**Yield**	**Test Weight**	**Seed Weight**	**Seed size**		
	Aug. 8 | 40% of pods fully filled	13.5% moisture	13.5% moisture		> 0.715 cm	> 0.675 cm	< 0.635 cm
	% of canopy diseased	bu/ac	lbs/bu	seeds/pound	grams	grams	grams
1	5 a*	75 ab*	64.3	2050 a*	19 a*	69 a*	7 a*
2	4 a	78 a	64.3	2079 a	17 a	66 a	9 a
3	6 a	76 ab	64.5	2054 a	19 a	69 a	7 a
4	5 a	72 ab	64.5	2060 a	20 a	68 a	8 a
5	12 a	64 c	64.5	2086 a	20 a	67 a	8 a
6	7 a	70 bc	64.3	2100 a	17 a	64 a	9 a
F:	11.02	8.08	0.63	0.47	0.44	0.52	0.34
P>F:	< 0.0001	0.0001	0.6820	0.7916	0.8191	0.7574	0.8813
CV:	28.6	5.9	0.6	3.4	23.4	10.7	47.6

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

Impact of adjuvants on efficacy of fungicides delivered through drop nozzles for management of white mold in soybeans

Oakes, ND (2017)

Michael Wunsch, Jesse Hafner, Suanne Kallis, and Billy Kraft;
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Kelly Cooper, Leonard Besemann, and Heidi Eslinger;
North Dakota State University Robert Titus Research Farm, Oakes, ND

Row spacing:	21 inches (three rows per plot)
Plot size:	Plots were 5 feet wide (center-to-center) and 25 feet long. To avoid edge effects, the start and end of plots were marked with tall flags, and alleys were not cut. To permit transition zones were the boom was charged and turned off, a 20-foot distance separated treatment plots. The soybeans in the 20-foot distance separating treatment plots were mowed shortly before harvest. The final plot length was measured at harvest.
Agronomic details	
Tillage:	conventional; cultivated once with soil finisher
Previous crop:	sunflowers
Variety:	Dairyland 'DSR-0619/R2Y' (0.6 maturity)
Seeding rate:	165,000 pure live seeds/ac
Planting date:	May 4, 2017
Soil type:	Embden sandy loam
Supplemental fertilization:	Spread fertilizer with Gandy; 218 lb/acre; 10-18-23-7; N=21.2 lbs, P=40 lbs, K=50 lbs, S=15 lbs/acre
Rhizobium inoculant:	Granular Rhizobium inoculant was applied in-furrow with the seed at planting in accordance with the manufacturer's directions.
Maintenance herbicide applications:	PRE: Spartan/Authority 19 oz/ac on 5/6/17 POST: 32 oz Roundup PowerMax + AMS 10 lbs/100 gal + NIS 1 pt/100 gal + Interlock 4 oz/ac 5/31/17
Harvest and seed yield and quality assessment	
Harvest:	September 28, 2017
Sclerotia contamination of grain:	Contamination of grain with sclerotia was assessed prior to grain cleaning by manually removing all sclerotia from an approx. 300-gram subsample of grain from each plot. To facilitate more efficient assessment of sclerotia contamination, the subsample was sieved with a upper sieve with 20/64" round holds and a lower sieve with 4.5/64 x 0.5/64 slotted holes (Seedburo Eqpt. Co.; Des Plaines, IL), and the portion of the sample that passed through the upper sieve but not the lower sieve was evaluated. All sclerotia, debris, and grain in the sieved subsample were weighed; the final sample of grain evaluated (after sclerotia and debris were manually removed) averaged 306 grams (minimum, 290 grams; maximum, 320 grams).
Yield and test weight:	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% moisture level.
Disease establishment	

The trial was planted on ground with a previous history of Sclerotinia disease outbreaks. Overhead irrigation was delivered through an overhead linear irrigator, with irrigation applied aggressively to facilitate apothecia production and Sclerotinia disease development.

Fungicide treatment imposition	
Fungicide applied:	Endura 70WG at 5.5 oz/ac
Application methods:	Fungicides were applied with a tractor-mounted boom equipped with pulse-width modulation system (Capstan AG; Topeka, KS). Fungicides were applied with '360 Undercover' drop nozzles ((360 Yield Center; Morton, IL) equipped with **XR11001VS flat-fan nozzles** on the side ports and **TX-VK3 hollow-cone nozzles** on the lower rear port (TeeJet Technologies, Spraying Systems Company; Glendale Heights, IL). The drop nozzles were spaced 21 inches apart, and the tractor was driven such that the drop nozzles were centered between rows. Application pressure was **60 psi**, driving speed was 4 **mph,** pulse width was **55%**, spray volume was **15 gal/ac,** and the boom was set so that the nozzles (mounted on the drop nozzles) were 9 inches above the ground**.**
Adjuvants:	TREATMENT #3: 0.25% v/v Silkin (alkylphenol ethoxylate, polyether-modified polysiloxane, and propylene glycol, 99% by volume; WinField Solutions, St. Paul, MN). *Silkin is an organosilicone nonionic surfactant.*
	TREATMENT #4: 6.4 fl oz/ac Masterlock (modified vegetable oil, polyoxyethylene sorbitan fatty acid ester, vefetable oil, and soybean oil, ethoxylated, 100% by volume; WinField Solutions, St. Paul, MN). *Masterlock is a non-ionic surfactant and drift-control adjuvant.*
Application timing:	July 12 at 3:45-4:30 pm; 100% of plants at R2 growth stage; canopy height = 26 inches; canopy closure = average 96% (minimum, 94%; maximum, 98%); air temperature = 70˚F, relative humidity = 64-65%, wind speed = 12-13 mph.

Fungicide treatment imposition	
Phytotoxicity:	Percent crop injury compared to the non-treated check was assessed August 2 and 10. A rating of zero indicates no crop injury.
Disease assessment:	**Sclerotinia stem rot (white mold) was assessed on September 27 when soybeans were at the R9 growth stage**. All plants in two of three rows per plot (the middle row and the row farthest from the tractor) were individually assessed for Sclerotinia stem rot severity using a 0 to 4 scale representing the percentage of the plant impacted by Sclerotinia stem rot, where **0** = 0% of the plant impacted by Sclerotinia, **1** = 1-33%, **2** = 34-66%, **3** = 67-99%, **4** = 100%. Plant tissue was considered to be impacted by Sclerotinia stem rot if it exhibited symptoms of Sclerotinia and/or bore poorly filled or unfilled pods caused by one or more Sclerotinia lesions that girdled stem tissue below the pods. *An average of 128 plants per plot (minimum 82, maximum 196) were assessed.*

Statistical analysis

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. To meet model assumptions, a systematic natural-log transformation was applied to the Sclerotinia severity and Sclerotinia severity index data. All other data met model assumptions without systematic transformation. Single-degree-of-freedom contrasts were performed for all pairwise comparisons of isolates; to control the Type I error rate at the level of the experiment, the Tukey multiple comparison procedure was employed. Analyses were conducted with replicate and treatment as main factor effects, and they were implemented in PROC UNIVARIATE and PROC GLM of SAS (version 9.4; SAS Institute, Cary, NC).

Summary of Impacts of Adjuvants

Impact of adjuvants on the efficacy of fungicides delivered through drop nozzles for management of white mold in soybeans
Oakes, ND (2017)

Michael Wunsch, Jesse Hafner, Billy Kraft, and Suanne Kallis; North Dakota State University Carrington Research Extension Center, Carrington, ND
Kelly Cooper, Leonard Besemann, and Heidi Eslinger; North Dakota State University Robert Titus Research Farm, Oakes, ND

CREC 704 Funded by a grant from the North Dakota Soybean Council

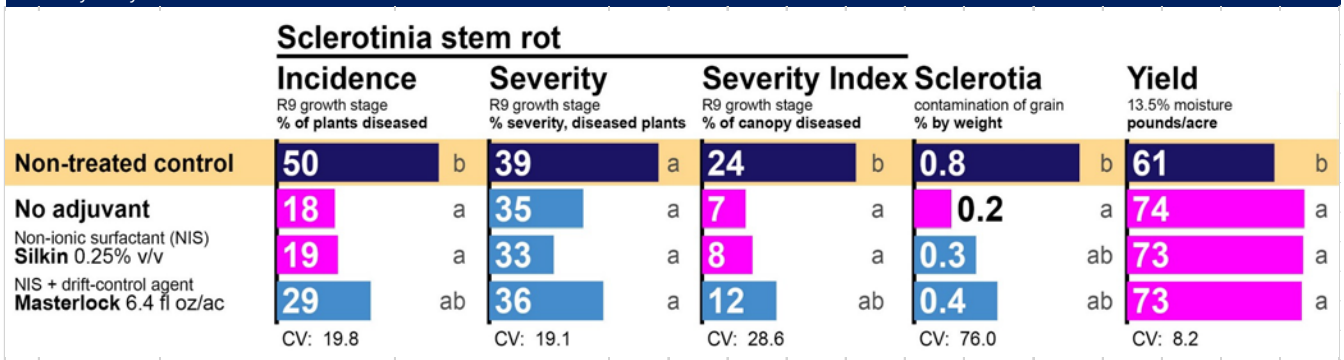
	Nozzle placement	Nozzle	Adjuvant	Sclerotinia stem rot: Incidence (Sept. 27 | R9 growth stage) %	Sclerotinia stem rot: Severity (Sept. 27 | R9 growth stage) %	Sclerotinia stem rot: Sev. Index (Sept. 27 | R9 growth stage) %	Sclerotia contamination of grain % by weight	Yield 13% moisture bu/ac	Test Weight 13% moisture lbs/bu
1	Non-treated			**50** b*‡	**44** a*	**24** b*‡	**0.8** b*	**61** b*	**59.6** b*
2	Drop nozzle	**XR11001VS** (side ports) + **TX-VK3** (lower rear port)	No adjuvant	**18** a	**36** a	**7** a	**0.2** a	**74** a	**59.6** ab
3	Drop nozzle	**XR11001VS** (side ports) + **TX-VK3** (lower rear port)	Silkin, 0.25% v/v	**19** a	**36** a	**8** a	**0.3** ab	**73** a	**59.8** a
4	Drop nozzle	**XR11001VS** (side ports) + **TX-VK3** (lower rear port)	Masterlock, 6.4 fl oz/ac	**29** ab	**37** a	**12** ab	**0.4** ab	**73** a	**58.9** b
			F:	4.73	1.37	4.21	4.32	6.75	3.47
			P>F:	0.0163	0.2895	0.0239	0.0220	0.0042	0.0429
			CV:	19.8	20.9	28.6	76.0	8.2	0.8

Fungicide applied: Endura 70WG 5.5 oz/ac **Spray volume:** 15 gal/ac **Driving speed:** 4 mph

*** 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.

Summary of key results



Fungicide: Endura 70WG 5.5 oz/ac
Application timing: July 12
100% R2 growth stage
canopy closure = 96%
canopy height = 26 inches

Fungicides applied with 'Undercover 360' drop nozzles (360 Yield Center)
Side ports: XR11001VS extended-range flat-spray nozzles
Lower rear ports: TX-VK3 hollow-cone nozles (lower rear port)
Pressure: 40 psi **Droplet size:** fine
Drop nozzle placement: centered between rows (21 in. apart); nozzles 9 in. above ground
Spray volume: 15 gal/ac **Driving speed:** 4.0 mph **Pulse width:** 55%

Soybean variety:
Dairyland 'DSR-0619/R27'
maturity = 0.6
Row spacing: 21 inches
Seeding rate: 165,000 pls/ac

Impact of nozzle placement, nozzle spray pattern, and droplet size on the efficacy of fungicides for management of white mold in soybeans

Oakes, ND (2017)

Michael Wunsch, Jesse Hafner, Suanne Kallis, and Billy Kraft;
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Kelly Cooper, Leonard Besemann, and Heidi Eslinger;
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Experimental design:	
Experimental design:	Randomized complete block with seven replicates. Double passes of guard plots were established on the edges of the trial, and every treatment plot was bordered on one side by a 5-foot-wide non-harvested buffer plot (so as to permit over-spray of treatments and to capture spray drift) and on the other side by two 5-foot-wide non-harvested plots (which were straddled by the tractor when fungicides were applied).
Row spacing:	21 inches (three rows per plot)
Plot size:	Plots were 5 feet wide (center-to-center) and 25 feet long. To avoid edge effects, the start and end of plots were marked with tall flags, and alleys were not cut. To permit transition zones were the boom was charged and turned off, a 20-foot distance separated treatment plots. The soybeans in the 20-foot distance separating treatment plots were mowed shortly before harvest. The final plot length was measured at harvest.
Agronomic details	
Tillage:	conventional; one time with soil finisher
Previous crop:	sunflowers
Variety:	Dairyland 'DSR-0619/R2Y' (0.6 maturity)
Seeding rate:	165,000 pure live seeds/ac
Planting date:	May 4, 2017
Soil type:	Embden and Maddock sandy loam
Supplemental fertilization:	Spread fertilizer with Gandy; 218 lb/acre; 10-18-23-7; N=21.2 lbs, P=40 lbs, K=50 lbs, S=15 lbs/acre
Rhizobium inoculant:	Granular Rhizobium inoculant was applied in-furrow with the seed at planting in accordance with the manufacturer's directions.
Maintenance herbicide applications:	PRE: Spartan/Authority 19 oz/ac n 5/6/17 POST: 32 oz Roundup PowerMax + AMS 10 lbs/100 gal + NIS 1 pt/100 gal 5/25/17
Harvest and seed yield and quality assessment	
Harvest:	September 18, 2017
Sclerotia contamination of grain:	Contamination of grain with sclerotia was assessed prior to grain cleaning by manually removing all sclerotia from an approx. 300-gram subsample of grain from each plot. To facilitate more efficient assessment of sclerotia contamination, the subsample was sieved with a upper sieve with 20/64" round holds and a lower sieve with 4/64 x 0.5/64 slotted holes (Seedburo Eqpt. Co.; Des Plaines, IL), and the portion of the sample that passed through the upper sieve but not the lower sieve was evaluated. All sclerotia, debris, and grain in the sieved subsample were weighed; the final sample of grain evaluated (after sclerotia and debris were manually removed) averaged 303 grams (minimum, 272 grams; maximum, 332 grams).
Yield and test weight:	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% moisture level.

Disease establishment

The trial was planted on ground with a previous history of Sclerotinia disease outbreaks. Overhead irrigation was delivered through an overhead linear irrigator, with irrigation applied aggressively to facilitate apothecia production and Sclerotinia disease development.

Fungicide treatment imposition

Fungicide applied: 5.5 oz/ac Endura 70WG (boscalid, 70% by weight; BASF Corp., Research Triangle Park, NC)

Adjuvant: 0.25% v/v Silkin (alkylphenol ethoxylate, polyether-modified polysiloxane, and propylene glycol, 99% by volume; WinField Solutions, St. Paul, MN). *Silkin is an organosilicone nonionic surfactant.*

Application methods: Fungicides were applied with a tractor-mounted boom equipped with pulse-width modulation system (Capstan AG; Topeka, KS). Driving speed was **4 mph**. The '360 Undercover' drop nozzle (360 Yield Center; Morton, IL) was utilized in treatments 3 to 9. All nozzles were obtained from TeeJet Technologies (Spraying Systems Company; Glendale Heights, IL).

Treatment 2: five boom-mounted **XR11004VS** flat-fan nozzles, each 20 in. apart; boom set 20 in. above the top of the canopy (46.9 in. above ground), **40 psi**, **38% pulse width**

Treatment 3: **XR11004VS** flat-fan nozzles on side ports of drop nozzle; nozzle height = 9 in. above the ground; **40 psi**, **20% pulse width**

Treatment 4: **XR11001VS** flat-fan nozzles on side ports of drop nozzle; nozzle height = 9 in. above the ground; **40 psi**, **100% pulse width**

Treatment 5: **XR8001VS** flat-fan nozzles on side ports of drop nozzle; nozzle height = 9 in. above the ground; **40 psi**, **100% pulse width**

Treatment 6: **TJ60-11002VS** twin-jet nozzles on side ports of drop nozzle; nozzle height = 9 in. above the ground; **40 psi**, **40% pulse width**

Treatment 7: **TX-VK6** hollow-cone nozzles on side ports of drop nozzle; nozzle height = 9 in. above the ground; **40 psi**, **100% pulse width**

Treatment 8: **XR11001VS** flat-fan nozzles on side ports of drop nozzle; nozzle height = 9 in. above the ground; **60 psi**, **78% pulse width**

Treatment 9: **XR11001VS** flat-fan nozzles on the side ports plus **TX-VK3** hollow-cone nozzle on the lower rear port of the drop nozzle; nozzle height = 9 inches above the ground; **60 psi**, **55% pulse width**

Application timing: July 12 at 9:30 am - 3:30 pm; 100% of plants at R2 growth stage; canopy height = 26 inches; canopy closure = average 96% (minimum, 94%; maximum, 98%); air temperature = 68-70˚F, relative humidity = 65-70%, wind speed = 12-13 mph.

Fungicide treatment imposition

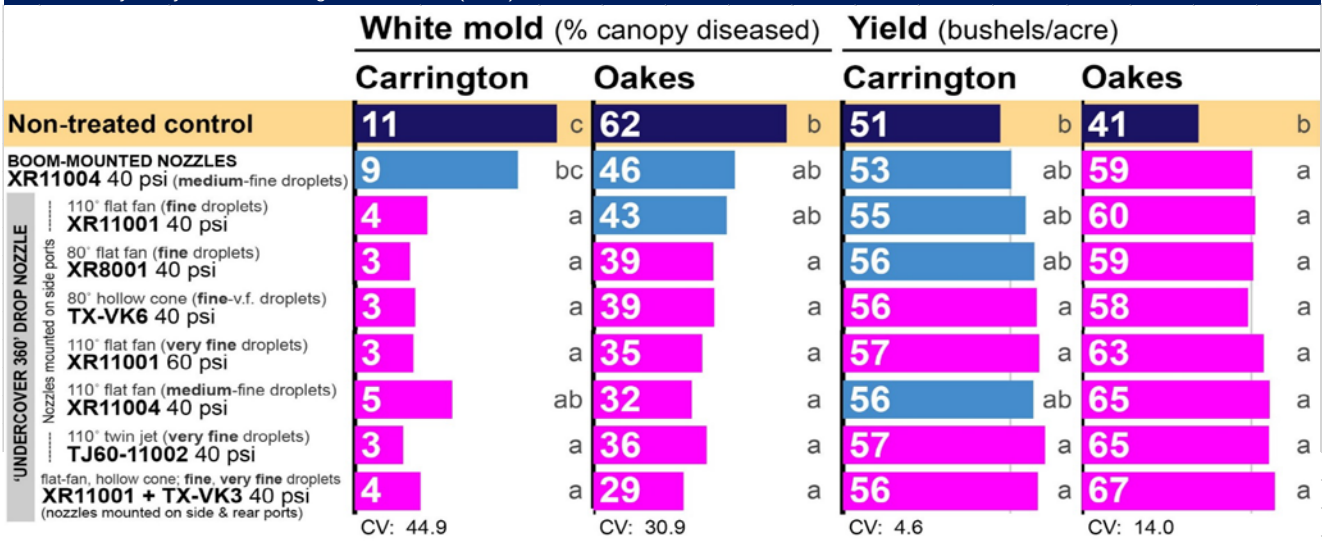
Impact of nozzle placement, nozzle spray pattern, and droplet size on the efficacy of fungicides for management of white mold in soybeans
Oakes, ND (2017)

	Nozzle placement	Nozzle (nozzle placement)	Application pressure	Sclerotinia stem rot Incidence	Sclerotinia stem rot Severity	Sclerotinia stem rot Sev. Index	Sclerotia contamination of grain	Yield	Test Weight
				Aug. 31 - Sept. 1 | R7 growth stage				13% moisture	
				%	%	%	% by weight	bu/ac	lbs/bu
1	Non-treated			**86** b*	**72** b*	**62** b*	**1.9** b*	**41** b*	**59.7** b*
2	Boom	**XR11004VS**	40 psi	**71** ab	**62** ab	**46** ab	**1.2** ab	**59** a	**60.1** ab
3	Drop nozzle	**XR11004VS** (side ports)	40 psi	**55** a	**57** a	**32** a	**0.7** a	**65** a	**60.0** ab
4	Drop nozzle	**XR11001VS** (side ports)	40 psi	**67** ab	**64** ab	**43** ab	**1.1** ab	**60** a	**60.2** a
5	Drop nozzle	**XR8001VS** (side ports)	40 psi	**65** ab	**60** ab	**39** a	**1.1** ab	**59** a	**59.9** ab
6	Drop nozzle	**TJ60-11002VS** (side ports)	40 psi	**60** ab	**61** ab	**36** a	**0.7** a	**65** a	**60.1** ab
7	Drop nozzle	**TX-VK6** (side ports)	40 psi	**62** ab	**61** ab	**39** a	**1.0** ab	**58** a	**60.0** ab
8	Drop nozzle	**XR11001VS** (side ports)	60 psi	**58** a	**59** a	**35** a	**0.9** a	**63** a	**60.0** ab
9	Drop nozzle	**XR11001VS** (side ports), **TX-VK3** (lower rear port)	40 psi	**51** a	**55** a	**29** a	**0.7** a	**67** a	**59.9** ab
			F:	3.21	3.02	4.44	3.45	6.25	2.18
			P>F:	0.0054	0.0079	0.0004	0.0033	< 0.0001	0.0456
			CV:	24.0	12.0	30.9	50.8	14.0	0.5

Fungicide applied: Endura 70WG 5.5 oz/ac **Adjuvant:** Silkin (non-ionic surfactant) at 0.25% v/v

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

Summary of key results - Carrington and Oakes (2017)



Variety: Dairyland 'DSR-0619/R27' (maturity = 0.6)
Row spacing: 21 inches
Seeding rate: 165,000 pls/ac
Fungicide: Endura 70WG 5.5 oz/ac
Application timing, Carrington: July 24; 60% R2 & 40% R3, 95% canopy closure
Application timing, Oakes: July 12, 100% R2, 96% canopy closure
Fungicides applied with 'Undercover 360' drop nozzles (360 Yield Center): Drop nozzle placement = between rows (21 in. apart); nozzles 8 in. above ground
Fungicides applied with boom-mounted XR11004 nozzles: Nozzle height = 20 inches above the canopy, nozzle spacing = 20 inches apart
Spray volume: 15 gal/ac **Driving speed:** 4.0 mph

Impact of spray volume on the efficacy of fungicides delivered through drop nozzles for management of white mold in soybeans

Oakes, ND (2017)

Michael Wunsch, Jesse Hafner, Suanne Kallis, and Billy Kraft;
North Dakota State University Carrington Research Extension Center, Carrington, ND
Kelly Cooper, Leonard Besemann, and Heidi Eslinger;
North Dakota State University Robert Titus Research Farm, Oakes, ND

Experimental design:	
Experimental design:	Randomized complete block with nine replicates. Double passes of guard plots were established on the edges of the trial, and every treatment plot was bordered on one side by a 5-foot-wide non-harvested buffer plot (so as to permit over-spray of treatments and to capture spray drift) and on the other side by two 5-foot-wide non-harvested plots (which were straddled by the tractor when fungicides were applied).
Row spacing:	21 inches (three rows per plot)
Plot size:	Plots were 5 feet wide (center-to-center) and 25 feet long. To avoid edge effects, the start and end of plots were marked with tall flags, and alleys were not cut. To permit transition zones were the boom was charged and turned off, a 20-foot distance separated treatment plots. The soybeans in the 20-foot distance separating treatment plots were mowed shortly before harvest. The final plot length was measured at harvest.
Agronomic details	
Tillage:	Conventional; once with soil finisher
Previous crop:	Sunflower
Variety:	Dairyland 'DSR-0619/R2Y' (0.6 maturity)
Seeding rate:	165,000 pure live seeds/ac
Planting date:	May 4, 2017
Soil type:	Hecla sandy loam
Supplemental fertilization:	Spread fertilizer with Gandy; 218 lb/acre; 10-18-23-7; N=21.2 lbs, P=40 lbs, K=50 lbs, S=15 lbs/acre
Rhizobium inoculant:	Granular Rhizobium inoculant was applied in-furrow with the seed at planting in accordance with the manufacturer's directions.
Maintenance herbicide applications:	PRE: Spartan/Authority 19 oz/ac on 5/6/17 POST: 32 oz Roundup PowerMax + AMS 10 lbs/100 gal + NIS 1 pt/100 gal + Interlock 4 oz/ac 5/31/17
Harvest and seed yield and quality assessment	
Harvest:	
Sclerotia contamination of grain:	Contamination of grain with sclerotia was assessed prior to grain cleaning by manually removing all sclerotia from an approx. 300-gram subsample of grain from each plot. To facilitate more efficient assessment of sclerotia contamination, the subsample was sieved with a upper sieve with 20/64" round holds and a lower sieve with 4.5/64 x 0.5/64 slotted holes (Seedburo Eqpt. Co.; Des Plaines, IL), and the portion of the sample that passed through the upper sieve but not the lower sieve was evaluated. All sclerotia, debris, and grain in the sieved subsample were weighed; the final sample of grain evaluated (after sclerotia and debris were manually removed) averaged 303 grams (minimum, 285 grams; maximum, 318 grams).
Yield and test weight:	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% moisture level.

Fungicide treatment imposition	
Fungicide applied:	Endura 70WG at 5.5 oz/ac
Adjuvant:	0.25% v/v Silkin (alkylphenol ethoxylate, polyether-modified polysiloxane, and propylene glycol,
Application methods:	Fungicides were applied with a tractor-mounted boom equipped with pulse-width modulation
	Treatment 2: spray volume = 6.8 gal/ac; pulse width = 28%
	Treatment 3: spray volume = 10.2 gal/ac; pulse width = 50%
	Treatment 4: spray volume = 13.6 gal/ac; pulse width = 68%
	Treatment 5: spray volume = 17.0 gal/ac; pulse width = 100%
Application timing:	July 12 at 4:30-6:00 pm; 100 of plants at R2 growth stage; canopy height = 26 inches; canopy closure = average 96% (minimum, 94%; maximum, 98%); air temperature = 68-70˚F, relative humidity = 65-70%, wind speed = 12-13 mph.

Fungicide treatment imposition	
Phytotoxicity:	Percent crop injury compared to the non-treated check was assessed August 2 and 10. A rating of zero indicates no crop injury.
Disease assessment:	**Sclerotinia stem rot (white mold) was assessed on September 27 when soybeans were at the R9 growth stage**. All plants in two of three rows per plot (the middle row and the row farthest from the tractor) were individually assessed for Sclerotinia stem rot severity using a 0 to 4 scale representing the percentage of the plant impacted by Sclerotinia stem rot, where **0** = 0% of the plant impacted by Sclerotinia, **1** = 1-33%, **2** = 34-66%, **3** = 67-99%, **4** = 100%. Plant tissue was considered to be impacted by Sclerotinia stem rot if it exhibited symptoms of Sclerotinia and/or bore poorly filled or unfilled pods caused by one or more Sclerotinia lesions that girdled stem tissue below the pods. *An average of 133plants per plot (minimum 108, maximum 171) were assessed.*

Summary of Drop Nozzle Efficacy

Impact of spray volume on the efficacy of fungicides delivered through drop nozzles for management of white mold in soybeans
Oakes, ND (2017)

				Sclerotinia stem rot					
				Incidence	Severity	Sev. Index	Sclerotia contamination of grain	Yield	Test Weight
				Sept. 27 | R9 growth stage				13% moisture	
	Nozzle placement	Nozzle	Spray volume	%	%	%	% by weight	bu/ac	lbs/bu
1	Non-treated			**2.5** a*	**38** a*	**1.0** a*‡	**0.02** a*	**69** a*	**59.1** b*
2	Drop nozzle	**XR11001VS** (side ports)	6.8 gal/ac	**2.0** a	**29** a	**0.6** a	**0.02** a	**71** a	**59.5** ab
3	Drop nozzle	**XR11001VS** (side ports)	10.2 gal/ac	**2.4** a	**39** a	**0.8** a	**0.03** a	**70** a	**59.6** ab
4	Drop nozzle	**XR11001VS** (side ports)	13.6 gal/ac	**2.8** a	**36** a	**1.1** a	**0.01** a	**69** a	**59.8** a
5	Drop nozzle	**XR11001VS** (side ports)	17.0 gal/ac	**2.8** a	**39** a	**1.2** a	**0.02** a	**70** a	**59.7** a
			F:	0.14	0.77	0.31	0.74	0.51	3.67
			P>F:	0.9657	0.5553	0.8694	0.5702	0.7273	0.0144
			CV:	112.6	29.9	98.1	130.5	4.5	0.7

Fungicide applied: Endura 70WG 5.5 oz/ac **Adjuvant:** 0.25% v/v Silkin non-ionic surfactant **Driving speed:** 4 mph

*** 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.

Optimizing fungicide deposition to sunflower heads for management of Sclerotinia head rot of confection sunflowers

Oakes, ND (2017)

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Previous crop:	potatoes
Planting date:	June 7
Variety:	'Jaguar DMR', a confection (non-oil) hybrid
Seeding rate:	60,000 seeds/ac; manually thinned to 17,400 plants/ac during early/mid vegetative growth. *We do not have precision planting capabilities on our small-plot planters; the sunflowers were overplanted and manually thinned in order to achieve optimal plant spacing of one plant every 12 inches.*
Date, growth stage when sunflowers were thinned:	V5 growth stage, thinned July 6-10, 2017
Experimental design:	Randomized complete block with four replicates.
Row spacing:	30 inches (two rows per plot)
Harvested plot size:	5 ft x approx. 19 ft = approx. 95 square feet
Plot layout:	The tractor used to apply fungicides drove over two rows of sunflowers. Fungicides were applied to the first three rows of sunflowers to the north of the tractor, with the second and third rows utilized for disease and yield assessments and the first row utilized for assessing spray deposition with water-sensitive spray cards affixed to the front of sunflower heads. The first and fourth rows to the north of the tractor pass were maintained as guard rows and were not assessed for disease or yield.
Weed control - herbicide applications:	Roundup 32 oz/acre June 7, Spartan 19 oz/acre June 7
Weed control - in-season cultivation:	*none*
Soil type:	Maddock Sandy Loam
Soil test results:	N-23, P-25, K-188, OM 2.3, pH-7.7
Supplemental fertilization:	April 5- 21lbs-N, 40lbs-P, 50 lbs S dry with gandy spreader, Sidedress 35lbs N June 16 as 28-0-0
Harvest:	October 11 *Due to the absence of a hard frost prior to this date, the sunflower heads had too much moisture to permit timely direct harvest with our sunflower plot combine. To ensure that the heads were harvested prior to lodging or bird predation, all heads in every treatment plot were manually clipped, bagged in burlap sacks, placed in dryers, and then passed through the combine. The heads were clipped and bagged for each study on October 11.*
Seed yield and quality evaluations:	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 quality results were adjusted from the grain actual moisture to a standard 10% moisture level.

Disease establishment	
Sclerotinia head rot:	To facilitate Sclerotinia head rot disease pressure, every sunflower head was inoculated with approx. 15,000 laboratory-produced ascospores of *Sclerotinia sclerotiorum* two and three days after fungicides were applied. Ascospore solutions were prepared by mixing ascospores collected on aluminum-foil disks with non-chlorinated water and a few drops of Tween 20, and the solution was diluted such that hand-held spray bottles that emitted 0.8 ml of liquid per spray would deliver approx. 5,000 spores per spray. Each head was inoculated with three sprays of the spray bottle, and overhead irrigation was applied with micro-sprinklers aggressively during the R5 and R6 growth stages and moderately during the R7 growth stage. Sunflowers were inoculated on **August 9 and 10** (except for one of the two rows of plots 205 and 305, which were inoculated on August 10 and 11)
Rust:	All rust disease pressure was due to natural infestation.
Fungicide treatment imposition	
Application methods:	Applications made with boom-mounted nozzles: Fungicides were applied with a 12-foot one-sided tractor-mounted boom. The boom was equipped with six **XR11002VS flat-fan nozzles** (TeeJet Technologies, Spraying Systems Company; Glendale Heights, IL) spaced 20 inches apart, with the 10-foot wide application width centered above the four-row treatment plot. Applications were made at 2.6 mph at a spray volume of **15 gallons/ac**, an application pressure of **40 psi**, and an application pulse width of 50 percent.
Application methods:	Applications were made with drop nozzles: Fungicides were applied with a one-sided tractor-mounted boom. The boom was equipped with four '360 Undercover' drop nozzles (360 Yield Center; Morton, IL) equipped with nozzleson the side ports or the side and lower rear ports of the drop nozzles. All spray nozzles were sourced from TeeJet Technologies (Spraying Systems Company; Glendale Heights, IL) on each of the two side ports of the drop nozzle. The drop nozzles were spaced 30 inches apart, with drop nozzles centered between the sunflower rows such that each of the two rows assessed for disease and yield and the row used to assess fuingicide deposition received fungicide applied from both sides of the row. Applications were made at **2.6 mph** at a spray volume of **15 gallons/ac**.
	Application specifics: '360 Undercover' drop nozzle with **XR11001VS** (flat-fan) nozzles on side ports at **40 psi (fine droplets)**, pulse width = 100, driving direction = **east** (90˚ from the north), adjuvant = **Silkin** (NIS), 0.25% v/v
	Boom height: Sunflowers exhibited differences in height across the footprints of each study. To ensure that fungicide applications through drop nozzles were made to the front of sunflower heads, the boom was manually raised or lowered such that (1) the spray nozzles were at approximately the mid-point of the sunflower heads at any given point or (2) the boom-mounted nozzles were approximately 20 inches above the predomionant canopy height at any given point.
	Sunflower growth stage: Sunflowers were at average R5.4 growth stage, with most plants at R5.2 to R5.6.
Treatment #1	**Luna Experience SC** 12.8 fl oz/ac + Silkin (NIS) 0.25% v/v
Treatment #2	**ProPulse SC** 10.3 fl oz/ac + Silkin (NIS) 0.25% v/v
Treatment #3	**Endura 70WG** 9 oz/ac + Silkin (NIS) 0.25% v/v
Treatment #4	**Proline SC** 5.7 fl oz/ac with no adjuvant
Treatment #5	**Proline SC** 5.7 fl oz/ac + Silkin (NIS) 0.25% v/v
Treatment #6	**Proline SC** 5.7 fl oz/ac + Masterlock (NIS + drift-control agent) 6.4 fl oz/ac
Treatment #7	**Non-treated control**
Application timing:	**August 7** at 1:00 to 4:00 pm; sunflower rust at trace levels, and no Sclerotinia head rot present; air temperature = 74-77˚F, relative humidity = 40-50%, wind speed = 3-4 mph.

Disease and phytotoxicity assessments	
Sclerotinia head rot disease assessment:	Sclerotinia head rot was assessed on August 28 at the late R6 growth stage, Sept.7 at the R7 growths tage, Sept. 28 at the R8 growth stage, and Oct. 10 and the R9 growth stage. In every plot, every plant was individually assessed for the percent of the sunflower head exhibiting symptoms of Sclerotinia head rot.
Shattered heads:	When Sclerotinia head rot is severe, diseased sunflower head tissue often shatters, resulting in the deposition of sunflower kernels on the ground prior to harvest. Concurrent with head rot disease assessments, every plant in every plot was individually assessed for the percent of the sunflower head that had shattered.
Rust:	The severity of sunflower rust was visually estimated on September 7 at the R7 growth stage (back of the heads yellow, bracts green). The percent of the leaf surface covered by rust pustules was assessed on the fourth, seventh, and tenth leaf from the top of the plant on each of five arbitrarily selected plants per plot.

Statistical analysis

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. Data that did not meet model assumptions were subjected to a systematic natural-log transformation; analysis was conducted on the transformed data, but, for ease of interpretation, treatment means were presented using non-transformed data in the table in the summary tab. Data that were subjected to a natural-log tranformation prior to analysis are identified with the ǂ symbol in the table in the summary tab. 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).

Management of Sclerotinia head rot of sunflowers: Fungicide efficacy and impact of adjuvants

Oakes, ND (2017)

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All treatments **Proline** 480SC 5.7 fl oz/ac + Silkin 0.25% v/v
15 gal/ac

SCLEROTINIA HEAD ROT

		Sclerotinia head rot			Sclerotinia head rot			Sclerotinia head rot			Sclerotinia head rot			Sclerotinia head rot	
		Incidence	Severity	Sev. Index	Incidence	Severity	Sev. Index	Incidence	Severity	Sev. Index	Incidence	Severity	Sev. Index	Incidence	Sev. Index
		Aug. 28 | late R6			Sept. 7 | R7			Sept. 28 | R8			October 10 | R9 growth stage			rAUDPC	rAUDPC
		%	%	%	%	%	%	%	%	%	%	%	%	0-100	0-100
1	Non-treated control	59	61	36	73	89	65	76	99	75	**75** a*	**98** a*	**74** a*	**59** a*	**51** a*
2	Boom-mounte XR11002VS, 40 psi	62	64	40	72	94	67	74	100	74	**74** a	**100** a	**74** a	**59** a	**53** a
3	Drop nozzles XR11002VS (side ports), 40 psi	54	57	31	68	88	60	71	100	71	**72** a	**99** a	**71** a	**55** a	**47** a
4	Drop nozzles XR11001VS (side ports), 40 psi	50	62	31	60	92	55	61	99	61	**62** a	**99** a	**61** a	**49** a	**43** a
5	Drop nozzles XR11001VS (side ports), 70 psi	48	62	29	63	91	57	65	99	65	**65** a	**100** a	**65** a	**50** a	**44** a
6	Drop nozzles XR11001VS (side ports) + TX-VK3 (lower rear	59	60	36	69	92	63	74	100	74	**75** a	**100** a	**75** a	**57** a	**50** a
	F:										1.41	0.82	1.29	1.08	1.00
	P>F:										0.2777	0.5551	0.3182	0.4092	0.4483
	CV:										13.5	1.6	13.9	15.7	16.7

SHATTERING OF DISEASED HEAD TISSUE

		Shattered heads			Shattered heads			Shattered heads			Shattered heads			Shattered heads	
		Incidence	Severity	Sev. Index	Incidence	Severity	Sev. Index	Incidence	Severity	Sev. Index	Incidence	Severity	Sev. Index	Incidence	Sev. Index
		Aug. 28 | late R6			Sept. 7 | R7			Sept. 28 | R8			October 10 | R9 growth stage			rAUDPC	rAUDPC
		%	%	%	%	%	%	%	%	%	%	%	%	0-100	0-100
1	Non-treated control	6	58	4	35	59	21	55	62	34	**57** a*	**70** a*	**40** a*	**30** a*	**19** a*
2	Boom-mounte XR11002VS, 40 psi	2	20	0	41	60	25	63	66	42	**68** a	**72** a	**49** a	**33** a	**22** a
3	Drop nozzles XR11002VS (side ports), 40 psi	4	21	1	38	49	19	60	62	38	**62** a	**71** a	**43** a	**32** a	**19** a
4	Drop nozzles XR11001VS (side ports), 40 psi	1	30	0	34	61	21	49	71	34	**53** a	**75** a	**40** a	**26** a	**18** a
5	Drop nozzles XR11001VS (side ports), 70 psi	4	38	2	29	63	18	49	62	31	**55** a	**67** a	**38** a	**26** a	**16** a
6	Drop nozzles XR11001VS (side ports) + TX-VK3 (lower rear	1	65	1	34	53	19	58	67	39	**63** a	**70** a	**43** a	**30** a	**19** a
	F:										0.96	0.46	0.87	0.88	0.48
	P>F:										0.4708	0.8031	0.5214	0.5207	0.7838
	CV:										18.5	10.5	19.5	20.8	25.8

RUST, SEED YIELD AND SEED QUALITY

		Rust severity							
		4th leaf from top of plant	7th leaf from top of plant	10th leaf from top of plant	Yield	Test Weight	Contam-ination of grain with sclerotia	Yield	Test Weight
		Sept. 7 | R7 growth stage			with sclerotia contamination 10% moisture			out sclerotia contamina 10% moisture	
		%	%	%	lbs/ac	lbs/bu	% by weight	lbs/ac	lbs/bu
1	Non-treated control	**3.5** b*‡	**6.5** b*‡	**10.0** b*‡	**1309** a*	**21.3** a*	. a*	. a*	. a*
2	Boom-mounte XR11002VS, 40 psi	**0.2** a	**0.3** a	**1.3** a	**1281** a	**21.8** a	. a	. a	. a
3	Drop nozzles XR11002VS (side ports), 40 psi	**0.0** a	**0.1** b	**0.4** b	**1473** a	**23.0** a	. a	. a	. a
4	Drop nozzles XR11001VS (side ports), 40 psi	**0.0** a	**0.1** a	**0.4** a	**1564** a	**22.8** a	. a	. a	. a
5	Drop nozzles XR11001VS (side ports), 70 psi	**0.2** a	**0.4** a	**1.0** a	**1704** a	**22.2** a	. a	. a	. a
6	Drop nozzles XR11001VS (side ports) + TX-VK3 (lower rear	**0.1** a	**0.1** a	**0.3** a	**1220** a	**21.2** a	. a	. a	. a
	F:	26.68	39.64	23.80	1.28	2.02			
	P>F:	< 0.0001	< 0.0001	< 0.0001	0.3236	0.1342			
	CV:	69.2	48.0	43.6	23.3	4.7			

* 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.

Management of Sclerotinia head rot of sunflowers: Fungicide efficacy and impact of adjuvants
Oakes, ND (2017)

Michael Wunsch, Jesse Hafner, Suanne Kallis, and Billy Kraft;
North Dakota State University Carrington Research Extension Center, Carrington, ND

Kelly Cooper, Leonard Besemann, and Heidi Eslinger;
North Dakota State University Robert Titus Research Farm, Oakes, ND

Location of trial	
Description:	North Dakota State University Carrington Research Extension Center,Oakes Irrigation approximately 3 miles north of Carrington, ND
GPS coordinates:	46.070085, -98.091889
Agronomic details	
Tillage:	disked-april 30, soil finisher-May 2, multiweeded- June 5th
Previous crop:	potatoes
Planting date:	June 7
Variety:	'Jaguar DMR', a confection (non-oil) hybrid
Seeding rate:	60,000 seeds/ac; manually thinned to 17,400 plants/ac during early/mid vegetative growth. *We do not have precision planting capabilities on our small-plot planters; the sunflowers were overplanted and manually thinned in order to achieve optimal plant spacing of one plant every 12 inches.*
Date, growth stage when sunflowers were thinned:	V5 growth stage, thinned july 6-10, 2017
Experimental design:	Randomized complete block with five replicates.
Row spacing:	30 inches (two rows per plot)
Harvested plot size:	5 ft x approx. 19 ft = approx. 95 square feet
Plot layout:	The tractor used to apply fungicides drove over two rows of sunflowers. Fungicides were applied to the first three rows of sunflowers to the north of the tractor, with the second and third rows utilized for disease and yield assessments and the first row utilized for assessing spray deposition with water-sensitive spray cards affixed to the front of sunflower heads. The first and fourth rows to the north of the tractor pass were maintained as guard rows and were not assessed for disease or yield.
Weed control - herbicide applications:	Round-up 32 oz/acre- June 7th, Spartan 19 oz/acre-June 7th
Weed control - in-season cultivation:	*none*
Soil type:	Maddock Sandy Loam
Soil test results:	N-23, P-25, K-188, OM-2.3, pH-7.7
Supplemental fertilization:	april 5- 21lbs nitrogen, 40 lbs/P, 50lbs/K, 15 lbs sulfur-dry with gandy, sidedress 35lb nitrogen june 16 as 28-0-0
Harvest:	October 11 *Due to the absence of a hard frost prior to this date, the sunflower heads had too much moisture to permit timely direct harvest with our sunflower plot combine. To ensure that the heads were harvested prior to lodging or bird predation, all heads in every treatment plot were manually clipped, bagged in burlap sacks, placed in dryers, and then passed through the combine. The heads were clipped and bagged for each study on October 11.*
Seed yield and quality evaluations:	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 quality results were adjusted from the grain actual moisture to a standard 10% moisture level.
Disease establishment	
Sclerotinia head rot:	To facilitate Sclerotinia head rot disease pressure, every sunflower head was inoculated with approx. 15,000 laboratory-produced ascospores of *Sclerotinia sclerotiorum* two and three days after fungicides were applied. Ascospore solutions were prepared by mixing ascospores collected on aluminum-foil disks with non-chlorinated water and a few drops of Tween 20, and the solution was diluted such that hand-held spray bottles that emitted 0.8 ml of liquid per spray would deliver approx. 5,000 spores per spray. Each head was inoculated with three sprays of the spray bottle, and overhead irrigation was applied with micro-sprinklers aggressively during the R5 and R6 growth stages and moderately during the R7 growth stage. Sunflowers were inoculated on **August 9 and 10** (except for one of the two rows of plots 205 and 305, which were inoculated on August 10 and 11)
Rust:	All rust disease pressure was due to natural infestation.

Management of Sclerotinia head rot of sunflowers: Fungicide efficacy and impact of adjuvants

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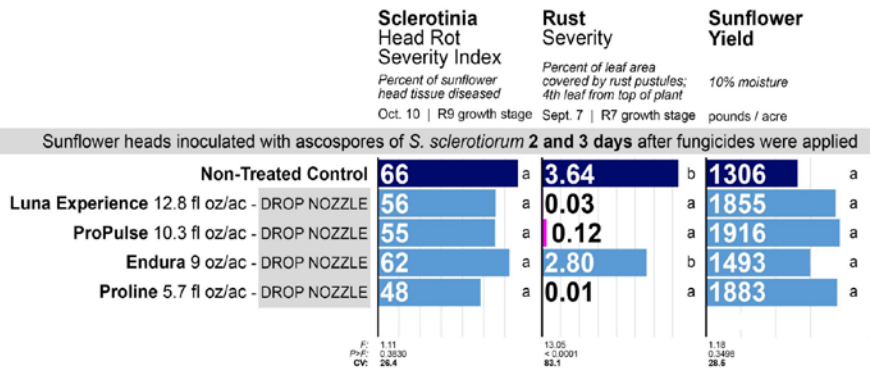
CREC 707: USDA SPECIALTY CROP BLOCK GRANT - Award Number NDDA 16-224

SUMMARY OF KEY RESULTS

(1) Fungicide efficacy.

Advjuvant: 'Silkin' NIS (Winfield Solutions) 0.25% v/v



Fungicide application timing: Aug. 7; average R5.4 growth stage

Fungicides applied with 'Undercover 360' drop nozzles (360 Yield Center)

Side ports: XR11001VS extended-range flat-spray nozzles

Pressure: 40 psi **Droplet size:** fine

Drop nozzle placement: centered between rows (30 in. apart); nozzles at average sunflower height

Spray volume: 15 gal/ac Driving speed: 2.6 mph Pulse width: 40%

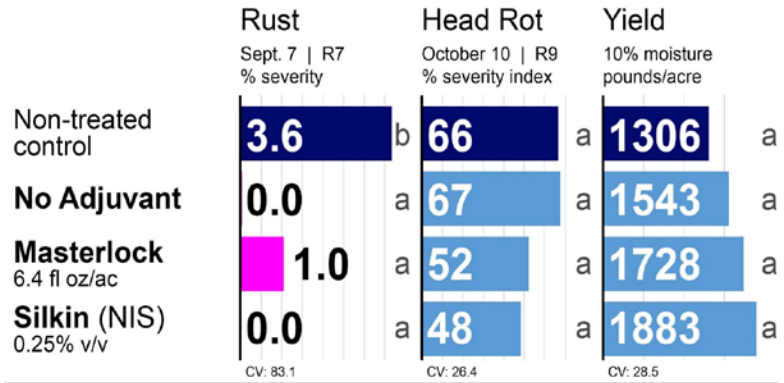
Hybrid: NuSeed 'Jaguar DMR' (confection type)

Row spacing: 30 inches

Plant population: 17,400 plants/ac

(2) Impact of adjuvants.

Fungicide: Proline 5.7 fl oz/ac



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Row spacing: 30 inches

Plant population: 17,400 plants/ac

			Sclerotinia head rot		Rust severity			Sclerotia
			Incidence	Sev. Index	4th leaf	Yield	Test Weight	contamination
			rAUDPC, Aug. 28-Oct. 10		Sept. 7 | R7	10% moisture		
			0-100	0-100	%	lbs/ac	lbs/bu	% by weight
1	**Luna Experience SC** 12.8 fl oz/ac	Silkin 0.25% v/v	**41** a*	**35** a*	**0.0** a*‡	**1855** a*	**22.6** a*	**8** a*
2	**ProPulse SC** 10.3 fl oz/ac	Silkin 0.25% v/v	**41** a	**35** a	**0.1** a	**1916** a	**23.1** a	**8** a
3	**Endura 70WG** 9 oz/ac	Silkin 0.25% v/v	**48** a	**42** a	**2.8** b	**1493** a	**22.1** a	**10** a
4	**Proline SC** 5.7 fl oz/ac	No adjuvant	**52** a	**44** a	**0.0** a	**1543** a	**21.9** a	**11** a
5	**Proline SC** 5.7 fl oz/ac	Silkin 0.25% v/v	**37** a	**32** a	**0.0** a	**1883** a	**22.4** a	**6** a
6	**Proline SC** 5.7 fl oz/ac	Masterlock 6.4 fl oz/ac	**40** a	**35** a	**1.0** a	**1728** a	**23.0** a	**7** a
7	**Non-treated control**		**50** a	**43** a	**4.0** b	**1363** a	**22.1** a	**11** a
		F:	0.86	0.67	13.80	1.08	1.23	1.45
		P>F:	0.5376	0.6748	< 0.0001	0.4036	0.3271	0.2367
		CV:	30.6	33.5	81.5	27.9	4.2	41.2

FUNGICIDE APPLIED (all treatments):
Proline 5.7 fl oz/ac
ADJUVANT APPLIED (all treatments):
Silkin NIS (Winfield Solutions) 0.25% v/v

			Sclerotinia head rot		Rust severity				
			Incidence	Severity Index	4th leaf from top of plant	7th leaf from top of plant	10th leaf from top of plant	Yield	Test Weight
			rAUDPC (Aug. 28-Oct. 10)		Sept. 7 | R7 growth stage			10% moisture	
			0-100	0-100	%	%	%	lbs/ac	lbs/bu
1	Non-treated control		**59** a*	**51** a*	**3.5** b*‡	**6.5** b*‡	**10.0** b*‡	**1309** a*	**21.3** a*
2	Boom-mounted	XR11002VS, 40 psi	**59** a	**53** a	**0.2** a	**0.3** a	**1.3** a	**1281** a	**21.8** a
3	Drop nozzles	XR11002VS (side ports), 40 psi	**55** a	**47** a	**0.0** a	**0.1** b	**0.4** b	**1473** a	**23.0** a
4	Drop nozzles	XR11001VS (side ports), 40 psi	**49** a	**43** a	**0.0** a	**0.1** a	**0.4** a	**1564** a	**22.8** a
5	Drop nozzles	XR11001VS (side ports), 70 psi	**50** a	**44** a	**0.2** a	**0.4** a	**1.0** a	**1704** a	**22.2** a
6	Drop nozzles	XR11001VS (side ports) + TX-VK3 (lower rear port), 40 psi	**57** a	**50** a	**0.1** a	**0.1** a	**0.3** a	**1220** a	**21.2** a
		F:	1.08	1.00	26.68	39.64	23.80	1.28	2.02
		P>F:	0.4092	0.4483	< 0.0001	< 0.0001	< 0.0001	0.3236	0.1342
		CV:	15.7	16.7	69.2	48.0	43.6	23.3	4.7

Effect of Plant Growth Hormones on Potato Tuber Uniformity

Dr. Mitchell J. Bauske and Dr. Andrew P. Robinson.
North Dakota State University, Department of Plant Sciences.

During the 2017 growing season, field trials were planted and maintained at two locations throughout North Dakota to evaluate the effect of plant growth regulators on potato tuber uniformity. Field trials were conducted at irrigated research sites at Oakes and Inkster, North Dakota were conducted with six conventional potato seed cultivars, including two russet cultivars, two chipping cultivars, and two red-skinned tablestock cultivars (Table 1). Treatments in all trials included seed and foliar applications of various plant growth regulators including gibberellic acid (GA), cytokinin, and Naphthaleneacetic acid (NAA).

Abstract

The application of plant growth hormones is known to alter stem number and tuber set in potatoes. Combinations of gibberellic acid, cytokinin, indole-3-butyric acid, and naphthaleneacetic acid were applied to six potato cultivars in field studies at two North Dakota locations. Stem numbers in Dakota Russet, Ivory Crisp, Atlantic, and Sangre increased with the application of growth hormones compared to the non-treated controls, although this increase was not statistically significant for each cultivar across field locations. Significant differences in tuber size distribution were also shown to result from hormone application. Gibberellic acid, cytokinin, and indole-3-butyric acid applied to Sangre potatoes resulted in a 126% increase in tubers per hectare sized 114 to 170 grams, and a 245% increase in tubers per hectare below 114 grams, compared to the non-treated control. When naphthaleneacetic acid was applied in combination with gibberellic acid, there was a 132% increase in Sangre tubers per hectare sized 114 to 170 grams. Only a 15% increase in below 114-gram tubers was observed with this combination, which was not a statistically significant increase in the number of smaller-sized tubers compared to the non-treated control. Length and width measurements of a 25-tuber subsample from each plot were also recorded. The length-to-width ratio of Sangre tubers treated with gibberellic acid, cytokinin, and indole-3-butyric acid was 1.25, significantly higher than 1.21 for non-treated Sangre tubers, resulting in a more elongated tuber shape. The combination of naphthaleneacetic acid and gibberellic acid resulted in a length-to-width ratio of 1.22, which was not significantly different from non-treated Sangre tubers. Results suggest that gibberellic acid may increase stem and tuber numbers in certain cultivars and result in more elongated tubers. Naphthaleneacetic acid decreases stem number and causes a rounder tuber shape compared to gibberellic acid alone, leading to a uniform tuber size distribution.

Table 1. Potato cultivars and hormone treatments evaluated in field trials to determine the effect of plant growth hormones on tuber uniformity in 2017.

Cultivar	**Market Class**
Dark Red Norland	Fresh Market Red
Sangre	Fresh Market Red
Ivory Crisp	Chipping
Atlantic	Chipping
Dakota Russet	Russet
Bannock Russet	Russet

Hormone	**Trade Name**	**Product Rate**	**Growth Stage**
Non-treated check	-	-	-
Gibberellic Acid + Cytokinin + Indole-3-butyric acid	Stimulate	20 fl oz/ton	**Seed Treatment**
Gibberellic Acid + Naphthaleneacetic Acid	ProGibb Rejuvenate	0.05 fl oz/ton 0.15 fl oz/ton	**Seed Treatment** **Seed Treatment**
Gibberellic Acid + Naphthaleneacetic Acid Gibberellic Acid + Cytokinin + Indole-3-butyric acid	ProGibb Rejuvenate Stimulate	0.05 fl oz/ton 0.15 fl oz/ton 6 oz/acre	**Seed Treatment** **Seed Treatment** Foliar (@ Dime Size Tubers + 10-14 days after application 1)

Preliminary yield data for Oakes, ND

Conventional trials at Oakes, ND were harvested on September 11 and at Inkster on October 3, 2017. Graded yield was subsequently determined. Graded yield results were analyzed in a two-way analysis of variance (ANOVA) and Fisher's protected least significant difference was determined in SAS (Statistical Analysis System; SAS Institute Inc., Cary, NC.) version 9.4. Differences in total yield, marketable yield, and tuber size classes in pounds per plot (lbs/plot) and number of tubers per plot (tuber number/plot) were determined among treatments for each cultivar.

Table 2. Graded yield in pounds per plot (lb/plot 150 ft^2) of six conventional potato cultivars treated with cytokinin (Stimulate®), gibberellic acid (GA / ProGibb®) and naphthaleneacetic acid (NAA / Rejuvenate®), and the combination of all three compounds.

Treatment	Cultivar	<4 oz	4-6 oz	6-10 oz	10-14 oz	>14 oz	Total yield	Total marketable	US#1 >4 oz	US#2 >4 oz	>6 oz	>10 oz
						lb/plot (150 ft2)					%	
Non-treated	Bannock Rus.	23	21	32	16	6	99	75	75	0	55	23
Stimulate	Bannock Rus.	26	23	27	14	5	94	69	69	0	48	19
GA+NAA	Bannock Rus.	26	22	30	14	4	95	69	69	0	50	18
Combination	Bannock Rus.	25	22	28	9	5	89	64	64	0	47	16
LSD (*P*=0.05)		NS	NS	NS	7	NS	NS	NS	NS	NS	NS	NS
Non-treated	Dakota Rus.	18	39	76	30	7	171	153	153	0	67	22
Stimulate	Dakota Rus.	45	53	54	9	3	163	118	118	0	40	7
GA+NAA	Dakota Rus.	44	55	54	13	1	167	123	123	0	40	8
Combination	Dakota Rus.	47	52	55	10	4	169	122	122	0	41	8
LSD (*P*=0.05)		13	14	19	9	6	NS	23	23	NS	14	7
Non-treated	Atlantic	46	50	61	22	1	180	134	134	0	46	13
Stimulate	Atlantic	71	49	37	8	1	165	94	94	0	27	5
GA+NAA	Atlantic	64	49	49	6	1	169	105	105	0	33	4
Combination	Atlantic	70	46	51	10	1	178	109	109	0	35	6
LSD (*P*=0.05)		15	NS	18	11	NS	NS	28	28	NS	11	5

Table 2 continued												
Non-treated	Ivory Crisp	15	17	47	39	42	161	145	145	0	80	50
Stimulate	Ivory Crisp	21	29	57	30	12	149	128	128	0	66	29
GA+NAA	Ivory Crisp	31	36	67	30	8	173	141	141	0	61	22
Combination	Ivory Crisp	27	35	53	29	12	155	129	129	0	60	25
LSD (*P*=0.05)		9	9	15	NS	9	NS	NS	NS	NS	10	13
Non-treated	Dark Red Nor.	24	28	75	36	21	182	159	159	0	72	31
Stimulate	Dark Red Nor.	23	31	69	40	14	177	154	154	0	70	30
GA+NAA	Dark Red Nor.	27	37	75	35	8	182	155	155	0	65	24
Combination	Dark Red Nor.	30	35	66	23	7	162	131	131	0	59	19
LSD (*P*=0.05)		NS	9	NS	15	10	15	16	16	NS	9	12
Non-treated	Sangre	26	32	59	37	18	171	145	145	0	66	32
Stimulate	Sangre	46	37	53	25	11	172	126	126	0	52	21
GA+NAA	Sangre	71	46	49	17	6	189	118	118	0	38	12
Combination	Sangre	40	30	49	31	15	164	124	124	0	56	27
LSD (*P*=0.05)		13	9	NS	15	NS	25	NS	NS	NS	11	7

Table 3. Total number and number of tubers in each size class per plot (tuber number/plot 150 ft^2) of six conventional potato cultivars treated with cytokinin (Stimulate®), gibberellic acid (GA / ProGibb®) and naphthaleneacetic acid (NAA / Rejuvenate®), and the combination of all three compounds.

Treatment	Cultivar	<4 oz	4-6 oz	6-10 oz	10-14 oz	>14 oz	Total yield	Total marketable	US#1 >4 oz	US#2 >4 oz	>6 oz	>10 oz
		tuber number/plot (150 ft^2)									%	
Non-treated	Bannock Rus.	75	30	32	32	3	151	100	151	0	44	23
Stimulate	Bannock Rus.	85	36	27	28	2	159	95	149	0	35	18
GA+NAA	Bannock Rus.	75	30	26	23	2	139	82	129	0	36	18
Combination	Bannock Rus.	76	30	25	16	2	139	76	126	0	31	13
LSD (*P*=0.05)		NS	NS	NS	16	NS	NS	NS	NS	NS	NS	NS
Non-treated	Dakota Rus.	57	63	82	65	4	228	218	342	0	66	30
Stimulate	Dakota Rus.	124	77	51	17	1	259	147	269	0	27	7
GA+NAA	Dakota Rus.	126	84	54	25	0	273	164	294	0	30	10
Combination	Dakota Rus.	134	79	54	20	2	275	156	282	0	28	8
LSD (*P*=0.05)		38	NS	19	17	3	36	29	52	NS	14	8
Non-treated	Atlantic	142	79	63	44	1	298	186	313	0	37	15
Stimulate	Atlantic	215	76	38	15	0	334	129	238	0	16	5
GA+NAA	Atlantic	213	83	53	12	0	353	148	280	0	19	3
Combination	Atlantic	223	75	54	21	1	360	152	274	0	21	6
LSD (*P*=0.05)		43	NS	20	24	NS	33	45	71	NS	13	9
Non-treated	Ivory Crisp	46	26	45	76	18	160	183	229	0	87	58
Stimulate	Ivory Crisp	74	48	59	64	6	207	182	267	0	64	35
GA+NAA	Ivory Crisp	97	58	70	63	4	250	199	306	0	55	27
Combination	Ivory Crisp	88	55	53	58	5	221	176	265	0	53	29
LSD (*P*=0.05)		27	15	17	NS	4	40	NS	63	NS	21	20

Table 3
continued

Non-treated	Dark Red Nor.	80	45	77	75	10	236	216	312	0	69	36
Stimulate	Dark Red Nor.	80	49	72	82	7	235	216	310	0	69	38
GA+NAA	Dark Red Nor.	88	57	74	69	4	246	208	316	0	60	30
Combination	Dark Red Nor.	103	58	70	50	4	250	185	296	0	50	22
LSD (*P*=0.05)		NS	NS	NS	29	5	NS	28	NS	NS	15	15
Non-treated	Sangre	78	47	56	73	7	213	190	269	0	63	37
Stimulate	Sangre	151	57	52	50	5	281	168	260	0	38	19
GA+NAA	Sangre	236	69	48	35	3	367	156	261	0	23	10
Combination	Sangre	137	48	50	64	7	263	176	253	0	46	27
LSD (*P*=0.05)		48	18	NS	36	NS	58	NS	NS	NS	18	13

The six conventional cultivars evaluated at Oakes, ND included two russet cultivars (Bannock, Dakota), two chipping cultivars (Atlantic, Ivory Crisp), and two red cultivars (Dark Red Norland, Sangre).
The cultivar Bannock Russet was the only cultivar that was evaluated that did not show any significant differences among treatments receiving Stimulate®, GA and NAA, or all three, compared to the non-treated control plots (Table 2). There were also no significant differences in the number of Bannock Russet tubers in treatments receiving plant growth hormones compared to non-treated plots (Table 3). In fact, the combination treatments applied with all three plant growth hormones (Stimulate®, GA and NAA) had a significantly lower number and pounds per plot of 10-14 ounce tubers compared to non-treated control plots, but this was the only significant difference in Bannock Russet plots receiving plant growth hormones compared to non-treated controls. However, total and marketable yield in Bannock Russet plots was significantly lower compared to other cultivars in this study according to a two-way analysis of variance (data not shown), meaning all Bannock Russet plots, regardless of hormone application, were lower yielding compared to other cultivars.
The total yield from Dakota Russet plots receiving applications of plant growth hormones was not significantly different compared to non-treated plots (Table 2). Treated plots all had significantly higher pounds per plot of tubers weighing 4 ounces or less (Table 2). The total number of Dakota Russet tubers from plots receiving applications of GA and NAA or the combination of GA and NAA plus Stimulate® were significantly higher compared to non-treated Dakota Russet plots (Table 3).
The total pounds per plot of Atlantic and Ivory Crisp, the two chipping cultivars, treated with plant growth hormones was not significantly different compared to non-treated control plots of those cultivars (Table 2). Both chipping cultivars treated with plant growth hormones had a higher weight in pounds per plot of tubers weighing less than 4 ounces. The total number of tubers of each cultivar from treated plots weighing less than 4 ounces was also greater compared to non-treated control plots (Table 3). However, tubers were also more uniform, as the percentage of tubers weighing more than 10 ounces was significantly lower in treated plots of both chipping cultivars compared to non-treated control plots of each cultivar. Lower numbers of oversized tubers and higher numbers of <4-10 ounce tubers suggest an increase in tuber size uniformity.
The total number of tubers per plot of Dark Red Norland did not significantly differ among treatments. However, Sangre plots treated with growth hormones had significantly higher numbers of tubers compared to the check. The number of tubers in total was greater for plots receiving GA and NAA or the combinations of all three hormones compared to non-treated (Table 3).
Although, in many of these cultivars, the total yield and marketable yield in pound or number per plot of treated versus non-treated was not significantly different, there was prominent differences among size classes. Further data analysis among treatments is ongoing.

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