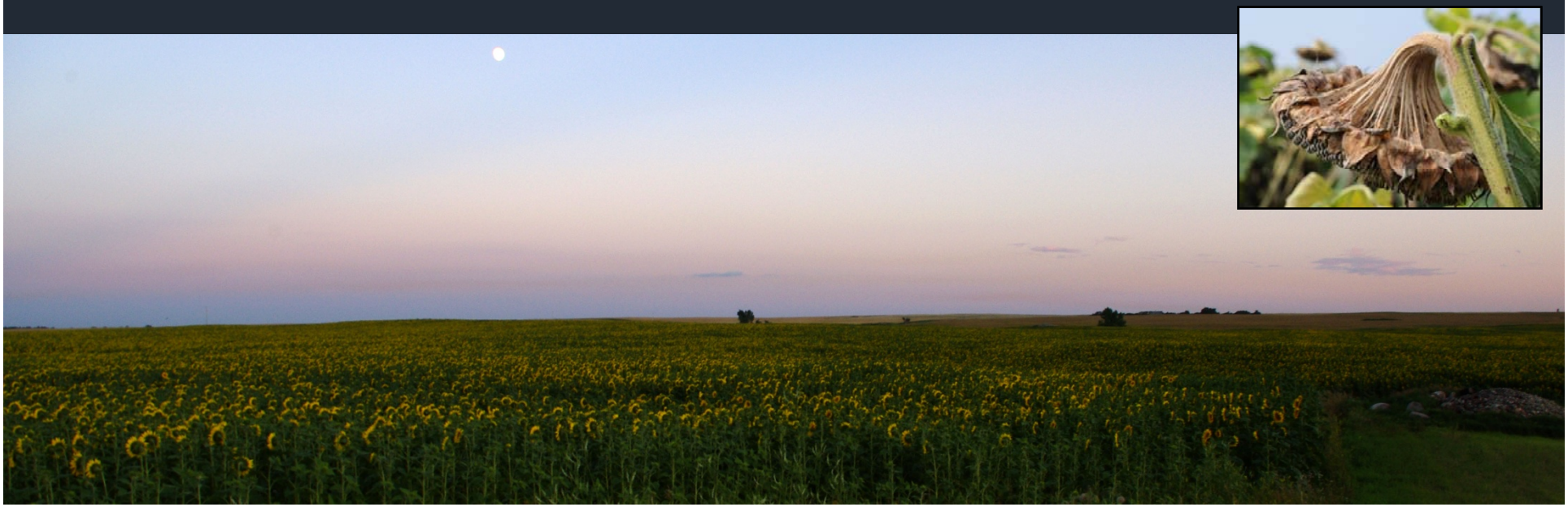
Prospects for using drop nozzles to facilitate the management of Sclerotinia head rot with fungicides:



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Objectives:

(1) Optimize application strategies to maximize fungicide deposition to the front of sunflower heads

(2) Identify which fungicide chemistries are most effective with this type of application method

(3) Identify when fungicides need to be applied in order to optimize disease control.

Challenges:

(1) Severe wind storms in Oakes caused problems with lodging, reducing the accuracy of yield data

(2) A severe hail storm in early July in Carrington resulted in significant stalk damage

- Sharply increased variability in plant heights
- Broke apical dominance in some plants
- Severely stunted plants and suckers were culled
  - Reduced bias but precluded yield assessments
  - Plot sizes had to be increased, reducing the number of treatments

Successes:

(1) Use of an spray card analysis program developed by researchers with the USDA-ARS in Ohio has permitted assessment of the spray volume deposited on sunflower heads

Optimizing fungicide deposition to sunflower heads

Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	**-**	**-**	**-**	**76 c**	**5.9 b**	**899 c**

Optimizing fungicide deposition to sunflower heads

Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	**-**	**-**	**-**	7 a	**2.9 c**	0.24 a

Optimizing fungicide deposition to sunflower heads

ALL TREATMENTS

FUNGICIDE:	**Proline** (prothioconazole)
ADJUVANT:	NIS, 0.25% v/v (**Silkin**; Winfield Solutions)
WATER VOLUME:	**15 gal/ac**

Treatment #2.

NOZZLE PLACEMENT:	**boom** (20-inch spacing)
NOZZLE TYPE:	TeeJet **XR8001VS f**lat-fan
PRESSURE:	**40 psi**
DROPLET SIZE:	**fine**

Optimizing fungicide deposition to sunflower heads
Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	-	-	**-**	76 c	5.9 b	**899 c**
2.	**Boom-mounted nozzles**	0.2 a	3 c	**0.01 a**	62 b	0.1 a	**1273 abc**

Optimizing fungicide deposition to sunflower heads

Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	7 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**

Optimizing fungicide deposition to sunflower heads

Treatment #3.

DROP NOZZLE:	**‘360 Undercover’**
NOZZLE PLACEMENT:	**side ports**
NOZZLE TYPE:	TeeJet **XR11001VS f**lat-fan
PRESSURE:	**40 psi**
DROPLET SIZE:	**fine**
DRIVING DIRECTION:	**East-Southeast** (Carrington)**, East** (Oakes)

Optimizing fungicide deposition to sunflower heads
Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	-	-	**-**	76 c	5.9 b	**899 c**
2.	**Boom-mounted nozzles**	0.2 a	3 c	**0.01 a**	62 b	0.1 a	**1273 abc**
3.	**XR11001, 40 psi, east**	4.0 a	23 abc	**3.9 a**	70 abc	0.1 a	**1549 ab**

Optimizing fungicide deposition to sunflower heads
Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	7 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**

Optimizing fungicide deposition to sunflower heads

Treatment #4

The same as treatment #3 except we drove the sprayer in the other direction.

DROP NOZZLE:	**‘360 Undercover’**
NOZZLE PLACEMENT:	**side ports**
NOZZLE TYPE:	TeeJet **XR11001VS f**lat-fan
PRESSURE:	**40 psi**
DROPLET SIZE:	**fine**
DRIVING DIRECTION:	**West-Northwest** (Carrington)**, West** (Oakes)

Optimizing fungicide deposition to sunflower heads
Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	-	-	**-**	76 c	5.9 b	**899 c**
2.	**Boom-mounted nozzles**	0.2 a	3 c	**0.01 a**	62 b	0.1 a	**1273 abc**
3.	**XR11001, 40 psi, east**	3.7 a	23 abc	**3.9 a**	70 abc	0.1 a	**1549 ab**
4.	**XR11001, 40 psi, west**	1.5 a	31 abc	**0.1 a**	70 abc	0.0 a	**985 bc**

Optimizing fungicide deposition to sunflower heads

Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	7 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**

Optimizing fungicide deposition to sunflower heads

Treatment #5

The same as treatment #3 except a higher application pressure.

DROP NOZZLE:	**‘360 Undercover’**
NOZZLE PLACEMENT:	**side ports**
NOZZLE TYPE:	TeeJet **XR11001VS f**lat-fan
PRESSURE:	**60 psi**
DROPLET SIZE:	**very fine**
DRIVING DIRECTION:	**East-Southeast** (Carrington)**, East** (Oakes)

Optimizing fungicide deposition to sunflower heads
Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	-	-	**-**	76 c	5.9 b	**899 c**
2.	**Boom-mounted nozzles**	0.2 a	3 c	**0.01 a**	62 b	0.1 a	**1273 abc**
3.	**XR11001, 40 psi, east**	3.7 a	23 abc	**3.9 a**	70 abc	0.1 a	**1549 ab**
4.	**XR11001, 40 psi, west**	1.5 a	31 abc	**0.1 a**	70 abc	0.0 a	**985 bc**
5.	**XR11001, 60 psi, east**	2.0 a	27 abc	**0.1 a**	68 abc	0.2 a	**1438 ab**

Optimizing fungicide deposition to sunflower heads
Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	7 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**
5.	**XR11001, 60 psi, SE**	19 a	128 a	**7.2 ab**	13 a	0.06 ab	**0.26 a**

Optimizing fungicide deposition to sunflower heads

Treatment #6

The same as treatment #5 except the sprayer was driven the other direction.

DROP NOZZLE:	**‘360 Undercover’**
NOZZLE PLACEMENT:	**side ports**
NOZZLE TYPE:	TeeJet **XR11001VS f**lat-fan
PRESSURE:	**60 psi**
DROPLET SIZE:	**very fine**
DRIVING DIRECTION:	**West-northwest** (Carrington)**, West** (Oakes)

Optimizing fungicide deposition to sunflower heads
Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	-	-	**-**	76 c	5.9 b	**899 c**
2.	**Boom-mounted nozzles**	0.2 a	3 c	**0.01 a**	62 b	0.1 a	**1273 abc**
3.	**XR11001, 40 psi, east**	3.7 a	23 abc	**3.9 a**	70 abc	0.1 a	**1549 ab**
4.	**XR11001, 40 psi, west**	1.5 a	31 abc	**0.1 a**	70 abc	0.0 a	**985 bc**
5.	**XR11001, 60 psi, east**	2.0 a	27 abc	**0.1 a**	68 abc	0.2 a	**1438 ab**
6.	**XR11001, 60 psi, west**	1.9 a	11 bc	**1.9 a**	74 cb	0.1 a	**869 c**

Optimizing fungicide deposition to sunflower heads
Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	8 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**
5.	**XR11001, 60 psi, SE**	15 a	172 a	**4.4 ab**	13 a	0.06 ab	**0.26 a**
6.	**XR11001, 60 psi, NW**	18 a	135 a	**3.0 ab**	9 a	0.01 a	**0.29 a**

Optimizing fungicide deposition to sunflower heads

Treatment #7

The same as treatment #5 except a different nozzle

DROP NOZZLE:	**‘360 Undercover’**
NOZZLE PLACEMENT:	**side ports**
NOZZLE TYPE:	TeeJet **TX-VK3** hollow-cone
PRESSURE:	**60 psi**
DROPLET SIZE:	**very fine**
DRIVING DIRECTION:	**East-southeast** (Carrington)**, East** (Oakes)

Optimizing fungicide deposition to sunflower heads
Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	-	-	**-**	76 c	5.9 b	**899 c**
2.	**Boom-mounted nozzles**	0.2 a	3 c	**0.01 a**	62 b	0.1 a	**1273 abc**
3.	**XR11001, 40 psi, east**	3.7 a	23 abc	**3.9 a**	70 abc	0.1 a	**1549 ab**
4.	**XR11001, 40 psi, west**	1.5 a	31 abc	**0.1 a**	70 abc	0.0 a	**985 bc**
5.	**XR11001, 60 psi, east**	2.0 a	27 abc	**0.1 a**	68 abc	0.2 a	**1438 ab**
6.	**XR11001, 60 psi, west**	1.9 a	11 bc	**1.9 a**	74 cb	0.1 a	**869 c**
7.	**TX-VK3, 60 psi, east**	11.5 a	65 ab	**12.3 a**	60 a	0.4 a	**1618 a**

Optimizing fungicide deposition to sunflower heads
Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	8 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**
5.	**XR11001, 60 psi, SE**	15 a	172 a	**4.4 ab**	13 a	0.06 ab	**0.26 a**
6.	**XR11001, 60 psi, NW**	18 a	135 a	**3.0 ab**	9 a	0.01 a	**0.29 a**
7.	**TX-VK3, side, SE**	15 ab	71 ab	**7.5 ab**	12 a	0.12 ab	**0.27 a**

Optimizing fungicide deposition to sunflower heads

Treatment #8

The same as treatment #7 except sprayer was driven in the opposite direction

DROP NOZZLE:	**‘360 Undercover’**
NOZZLE PLACEMENT:	**side ports**
NOZZLE TYPE:	TeeJet **TX-VK3** hollow-cone
PRESSURE:	**60 psi**
DROPLET SIZE:	**very fine**
DRIVING DIRECTION:	**West-northwest** (Carrington)**, West** (Oakes)

Optimizing fungicide deposition to sunflower heads

Oakes, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/ac
1.	**Non-treated control**	-	-	**-**	76 c	5.9 b	**899 c**
2.	**Boom-mounted nozzles**	0.2 a	3 c	**0.01 a**	62 b	0.1 a	**1273 abc**
3.	**XR11001, 40 psi, east**	3.7 a	23 abc	**3.9 a**	70 abc	0.1 a	**1549 ab**
4.	**XR11001, 40 psi, west**	1.5 a	31 abc	**0.1 a**	70 abc	0.0 a	**985 bc**
5.	**XR11001, 60 psi, east**	2.0 a	27 abc	**0.1 a**	68 abc	0.2 a	**1438 ab**
6.	**XR11001, 60 psi, west**	1.9 a	11 bc	**1.9 a**	74 cb	0.1 a	**869 c**
7.	**TX-VK3, 60 psi, east**	11.5 a	65 ab	**12.3 a**	60 a	0.4 a	**1618 a**
8.	**TX-VK3, 60 psi, west**	5.0 a	79 a	**0.6 a**	68 abc	0.1 a	**1203 abc**
	CV:	79.0	76.9	66.9	15.4	112.5	32.8

Optimizing fungicide deposition to sunflower heads

Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	8 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**
5.	**XR11001, 60 psi, SE**	15 a	172 a	**4.4 ab**	13 a	0.06 ab	**0.26 a**
6.	**XR11001, 60 psi, NW**	18 a	135 a	**3.0 ab**	9 a	0.01 a	**0.29 a**
7.	**TX-VK3, side, SE**	15 ab	71 ab	**7.5 ab**	12 a	0.12 ab	**0.27 a**
8.	**TX-VK3, side, NW**	11 abc	110 a	**5.9 ab**	6 a	0.20 b	**0.30 a**

Optimizing fungicide deposition to sunflower heads

Treatment #9

The same as treatment #7 except a third hollow-cone nozzle was added to the lower rear port of the drop nozzle.

DROP NOZZLE:	‘**360 Undercover’**
NOZZLE PLACEMENT:	**side ports and lower rear port**
NOZZLE TYPE:	TeeJet **TX-VK3** hollow-cone
PRESSURE:	**60 psi**
DROPLET SIZE:	**very fine**
DRIVING DIRECTION:	**East-southeast** (Carrington)

Optimizing fungicide deposition to sunflower heads
Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	8 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**
5.	**XR11001, 60 psi, SE**	15 a	172 a	**4.4 ab**	13 a	0.06 ab	**0.26 a**
6.	**XR11001, 60 psi, NW**	18 a	135 a	**3.0 ab**	9 a	0.01 a	**0.29 a**
7.	**TX-VK3, side, SE**	15 ab	71 ab	**7.5 ab**	12 a	0.12 ab	**0.27 a**
8.	**TX-VK3, side, NW**	11 abc	110 a	**5.9 ab**	6 a	0.20 b	**0.30 a**
9.	**TX-VK3, side+rear, SE**	20 a	98 a	**13.3 a**	10 a	0.03 a	**0.27 a**

Optimizing fungicide deposition to sunflower heads

Treatment #10

Boom-mounted applications were combined with a drop-nozzle application

DROP NOZZLE:	**‘360 Undercover’**
NOZZLE PLACEMENT:	**side ports of drop nozzle**
	30-inch spacing on the boom
NOZZLE TYPE:	TeeJet **XR8001VS** flat-fan (boom)
	TeeJet **TX-VK6** hollow-cone (drop nozzle)
PRESSURE:	**60 psi**
DROPLET SIZE:	**fine** (boom) / **very fine** (drop nozzle)
DRIVING DIRECTION:	**East-southeast** (Carrington)

Optimizing fungicide deposition to sunflower heads

Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm^2	Deposition µL/cm^2	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	8 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**
5.	**XR11001, 60 psi, SE**	15 a	172 a	**4.4 ab**	13 a	0.06 ab	**0.26 a**
6.	**XR11001, 60 psi, NW**	18 a	135 a	**3.0 ab**	9 a	0.01 a	**0.29 a**
7.	**TX-VK3, side, SE**	15 ab	71 ab	**7.5 ab**	12 a	0.12 ab	**0.27 a**
8.	**TX-VK3, side, NW**	11 abc	110 a	**5.9 ab**	6 a	0.20 b	**0.30 a**
9.	**TX-VK3, side+rear, SE**	20 a	98 a	**13.3 a**	10 a	0.03 a	**0.27 a**
10.	**Boom + TX-VK6**	11 abc	72 ab	**1.0 ab**	16 a	0.03 ab	**0.27 a**

Optimizing fungicide deposition to sunflower heads

Treatment #10

Boom-mounted applications were combined with a drop-nozzle application

DROP NOZZLE:	'**FK110 Plus 2'**
NOZZLE PLACEMENT:	**All three pairs of ports**
NOZZLE TYPE:	TeeJet **TX-VK4** hollow-cone (top ports)
	TeeJet **TX-VS1** hollow-cone (other ports)
PRESSURE:	**60 psi**
DROPLET SIZE:	**very fine**
DRIVING DIRECTION:	**East-southeast** (Carrington)

Optimizing fungicide deposition to sunflower heads

Carrington, ND

	TREATMENT	Coverage %	Droplets no./cm²	Deposition µL/cm²	Head Rot %	Rust %	Yield lb/head
1.	**Non-treated control**	-	-	**-**	8 a	2.9 c	**0.24 a**
2.	**Boom-mounted nozzles**	4 c	32 b	**0.2 b**	10 a	0.02 a	**0.26 a**
3.	**XR11001, 40 psi, SE**	14 ab	88 ab	**2.0 ab**	10 a	0.07 ab	**0.28 a**
4.	**XR11001, 40 psi, NW**	19 a	128 a	**7.2 ab**	9 a	0.02 a	**0.32 a**
5.	**XR11001, 60 psi, SE**	15 a	172 a	**4.4 ab**	13 a	0.06 ab	**0.26 a**
6.	**XR11001, 60 psi, NW**	18 a	135 a	**3.0 ab**	9 a	0.01 a	**0.29 a**
7.	**TX-VK3, side, SE**	15 ab	71 ab	**7.5 ab**	12 a	0.12 ab	**0.27 a**
8.	**TX-VK3, side, NW**	11 abc	110 a	**5.9 ab**	6 a	0.20 b	**0.30 a**
9.	**TX-VK3, side+rear, SE**	20 a	98 a	**13.3 a**	10 a	0.03 a	**0.27 a**
10.	**Boom + TX-VK6**	11 abc	72 ab	**1.0 ab**	16 a	0.03 ab	**0.27 a**
11.	**European drop nozzle**	4 bc	62 ab	**0.4 b**	10 a	0.20 b	**0.26 a**
	CV:	20.0	9.0	17.2	66.7	32.8	14.1

Fungicide application timing - Carrington, ND

Sunflowers were inoculated once at R5.7 to R5.9 growth stage:

- 84% of heads were inoculated Aug. 10
- 4% of heads were inoculated Aug. 12
- 12% of heads were inoculated Aug. 15