



## Optimizing fungicide applications for improved management of white mold in dry beans

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# Spray droplet size

**Cutting droplet diameter in half**



**=**

**Results in eight times as many droplets**

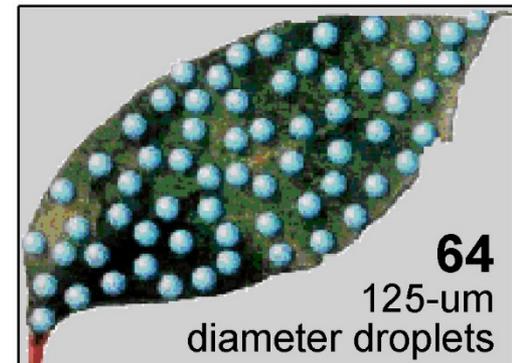
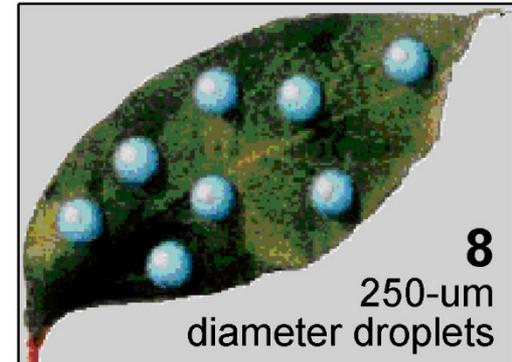
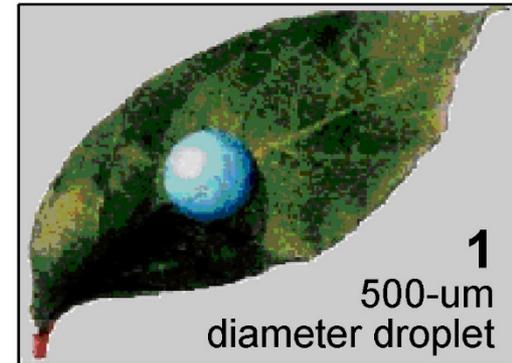
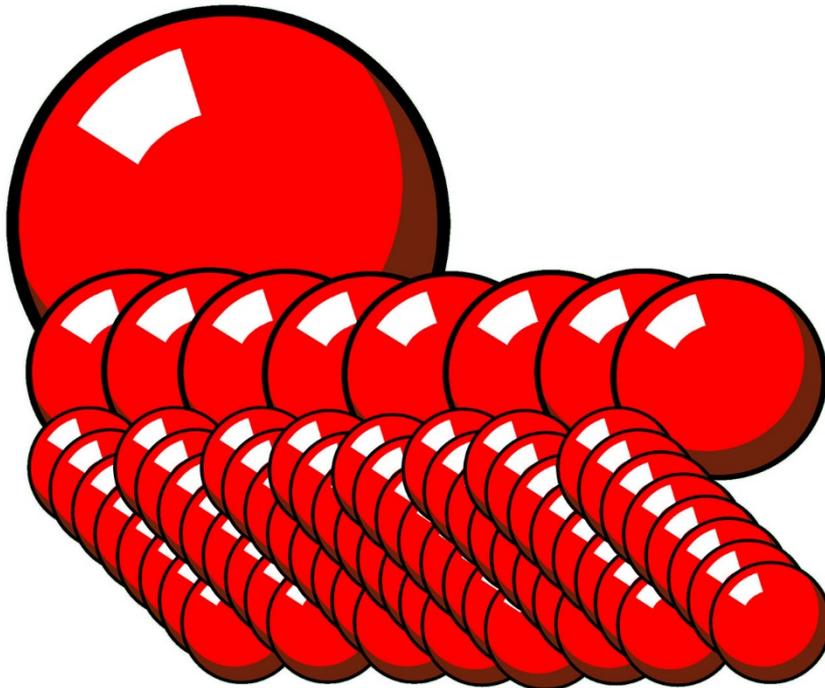


*(there is one more droplet in the rear)*

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN A CROP CANOPY

## Spray droplet size

**0.065 mm<sup>3</sup> spray volume =**  
**one** 500-um diameter droplet  
**eight** 250-um diameter droplets  
**sixty-four** 125-um diameter droplets

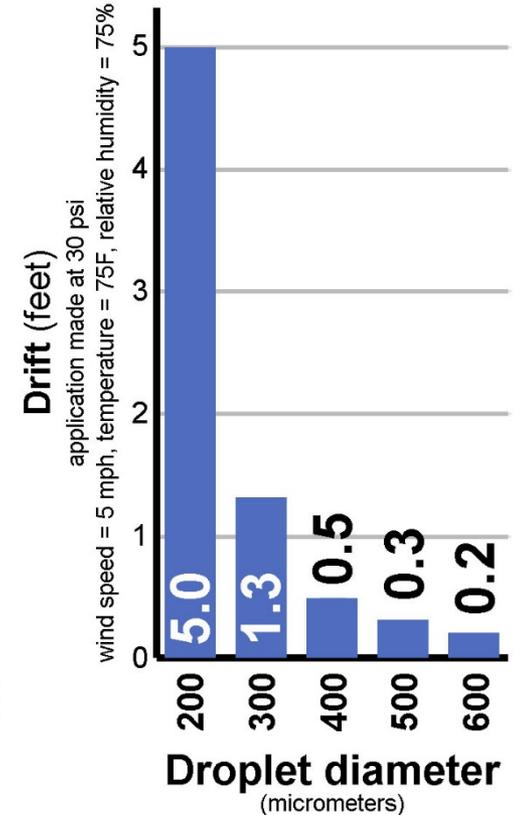
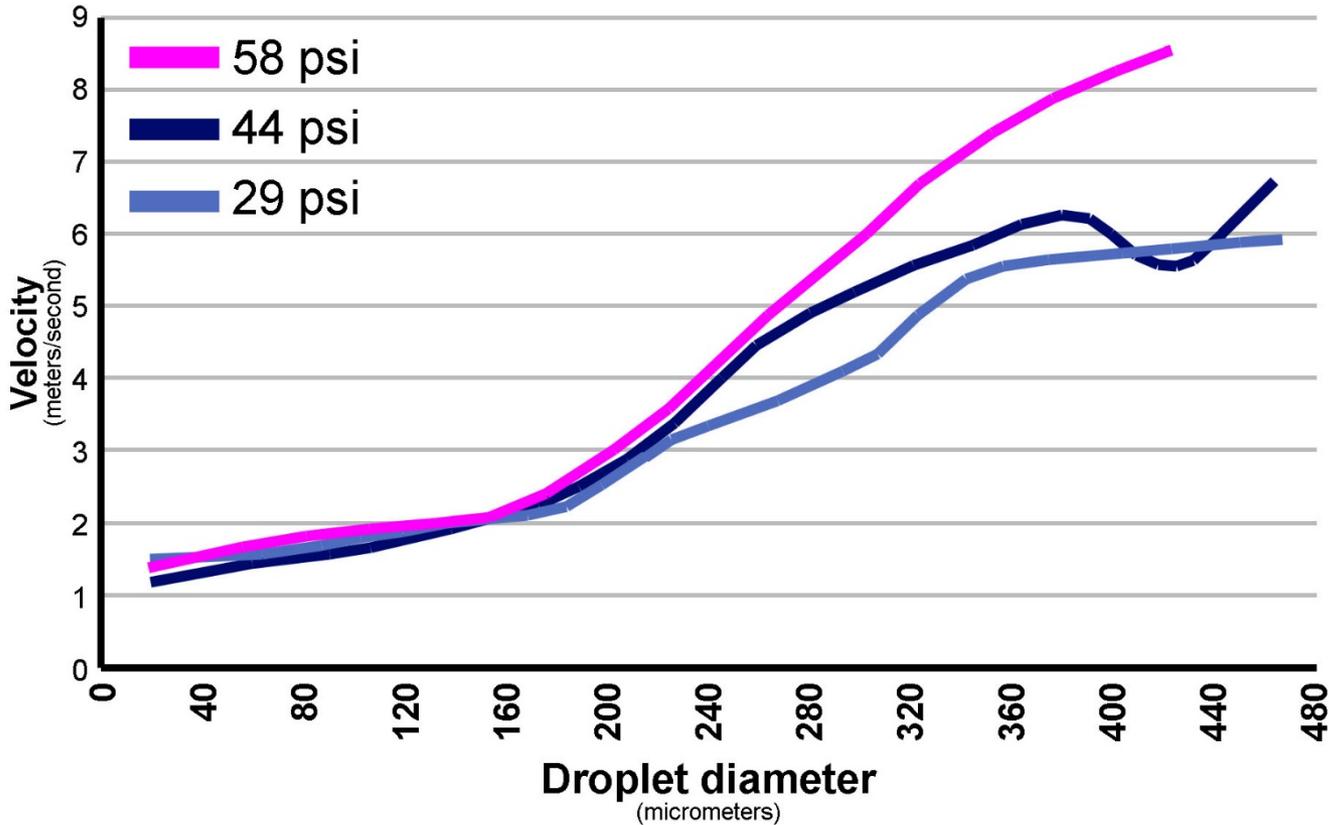


# OPTIMIZING FUNGICIDE DEPOSITION WITHIN A CROP CANOPY

## Spray droplet size

... but larger droplets have greater velocity, drift less.

*Increased velocity and reduced drift improves canopy penetration.*



## Experimental methods

- **Spraying Systems TeeJet extended-range flat-fan nozzles**
- **Tractor-mounted sprayer**
- **Constant driving speed (6.7 mph), spray volume (15 gal/ac)**
- **Pulse-width modulation system (Capstan AG)**
- **Pulse width calibrated and confirmed** by quantifying spray nozzle output

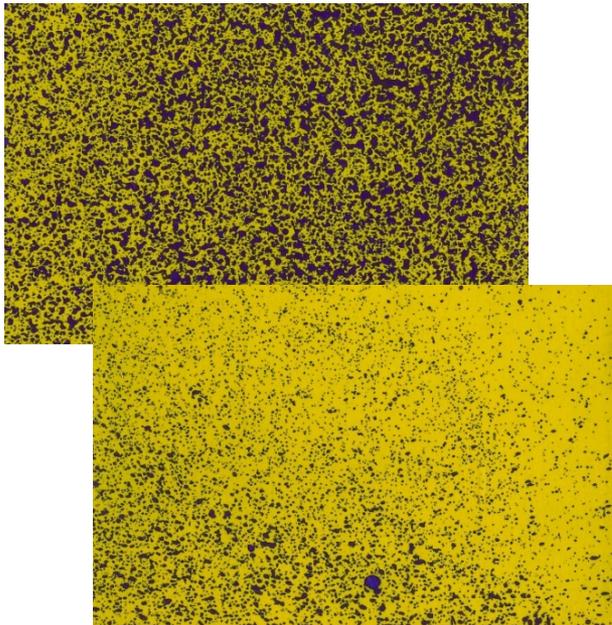


Spot-On sprayer calibrator model SC-1  
Innoquest, Inc.; Woodstock, IL

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN A CROP CANOPY

## Experimental methods

**Spray cards** were utilized to confirm that pulse width calibration was correct and that spray volume was consistent across treatments.



**July 18**

pinto, navy, black  
and kidney beans

**August 1**

navy, black  
and kidney beans

temperature: 73-80°F  
relative humidity: 55-64%  
wind: 4-7 mph

60-63°F  
58-70%  
8-10 mph

### Percent spray coverage

SPRAY CARDS placed at height of crop canopy

**XR8003** 50 psi  
FINE DROPLETS

21

a

22

a

**XR8004** 40 psi  
MEDIUM-FINE DROPLETS

21

a

22

a

**XR8006** 40 psi  
MEDIUM DROPLETS

22

a

25

a

**XR8008** 35 psi  
MEDIUM-COARSE DROPLETS

27

a

26

a

**XR8010** 30 psi  
COARSE DROPLETS

22

a

23

a

P>F: 0.0848  
CV: 7.3

0.8088  
23.1

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Impact of spray droplet size – NAVY BEANS

Carrington, ND (2018)

'Avalanche' navy beans

21-inch row spacing

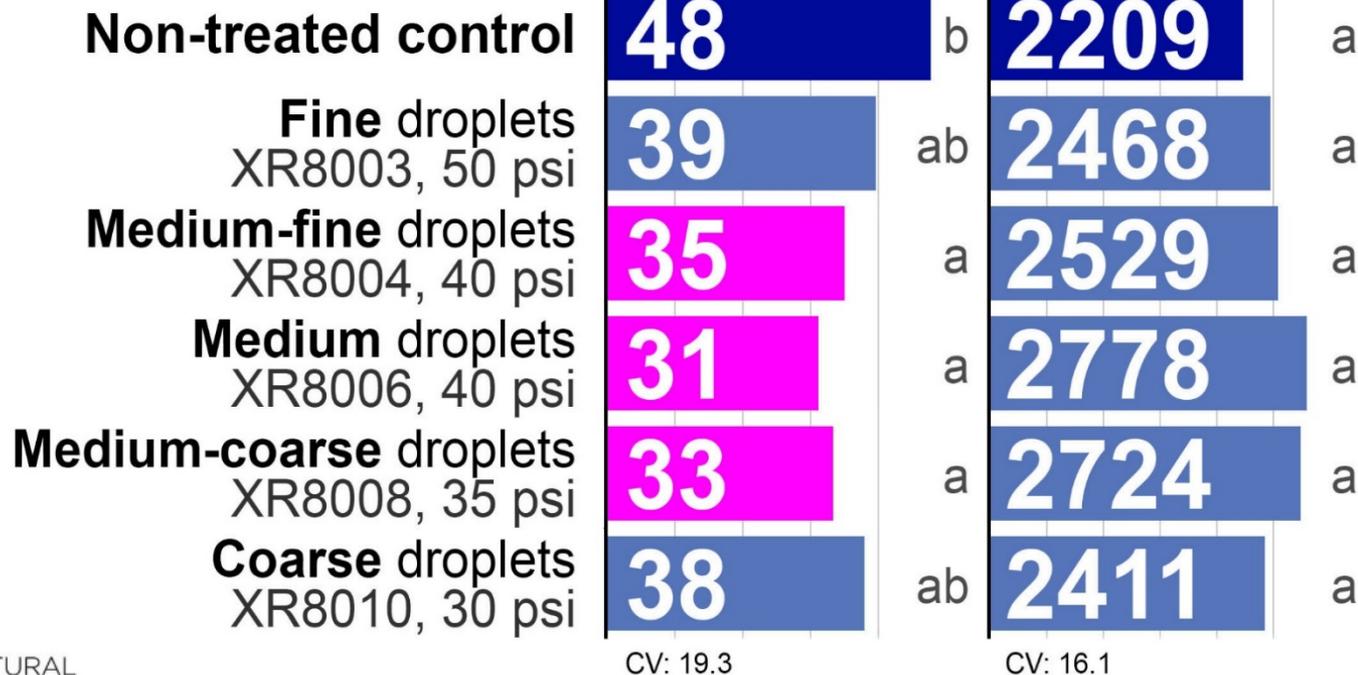
TWO FUNGICIDE APPLICATIONS

**White Mold**

**Yield (lbs/ac)**

% canopy diseased

13.5% moisture



**NDSU** NORTH DAKOTA AGRICULTURAL  
EXPERIMENT STATION



**Spray volume:** 15 gal/ac      **Driving speed:** 6.7 mph

First fungicide application (July 18):

**Endura 70WG 8 oz/ac**

Full bloom, average pod length 2 in. (max. 3.5 in.)  
**canopy closure = 90-98%**, canopy height = 19-24 in.  
73-80°F, 4-7 mph wind, 55-64% relative humidity

Second fungicide application (Aug. 1):

**Topsin 4.5FL 40 fl oz/ac**

Full bloom, average 21 full-length pods/plant  
**canopy closure = 100%**, canopy height = 13-19 inches  
60-63°F, 8-10 mph wind, 58-70% relative humidity

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Impact of spray droplet size – BLACK BEANS

Carrington, ND (2018)  
'Eclipse' black beans  
21-inch row spacing

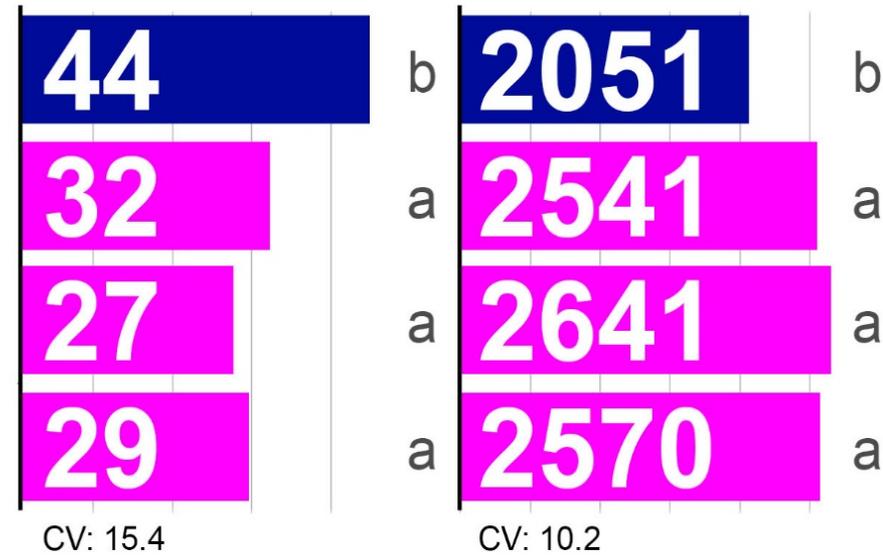
TWO FUNGICIDE APPLICATIONS

**Non-treated control**

**Fine droplets**  
XR8003, 50 psi  
**Medium droplets**  
XR8006, 40 psi  
**Coarse droplets**  
XR8010, 30 psi

**White Mold**

% canopy diseased



NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

**Spray volume:** 15 gal/ac

**Driving speed:** 6.7 mph

**First fungicide application (July 18):**

**Endura 70WG 8 oz/ac**

Full bloom, average pod length 2.5 in. (max. 4.0 in.)  
**canopy closure = 75-85%**, canopy height = 16-23 in.  
73-80°F, 4-7 mph wind, 55-64% relative humidity

**Second fungicide application (Aug. 1):**

**Topsin 4.5FL 40 fl oz/ac**

Full bloom, average 13 full-length pods/plant  
**canopy closure = 100%**, canopy height = 17-20 inches  
60-63°F, 8-10 mph wind, 58-70% relative humidity



# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Impact of spray droplet size – KIDNEY BEANS

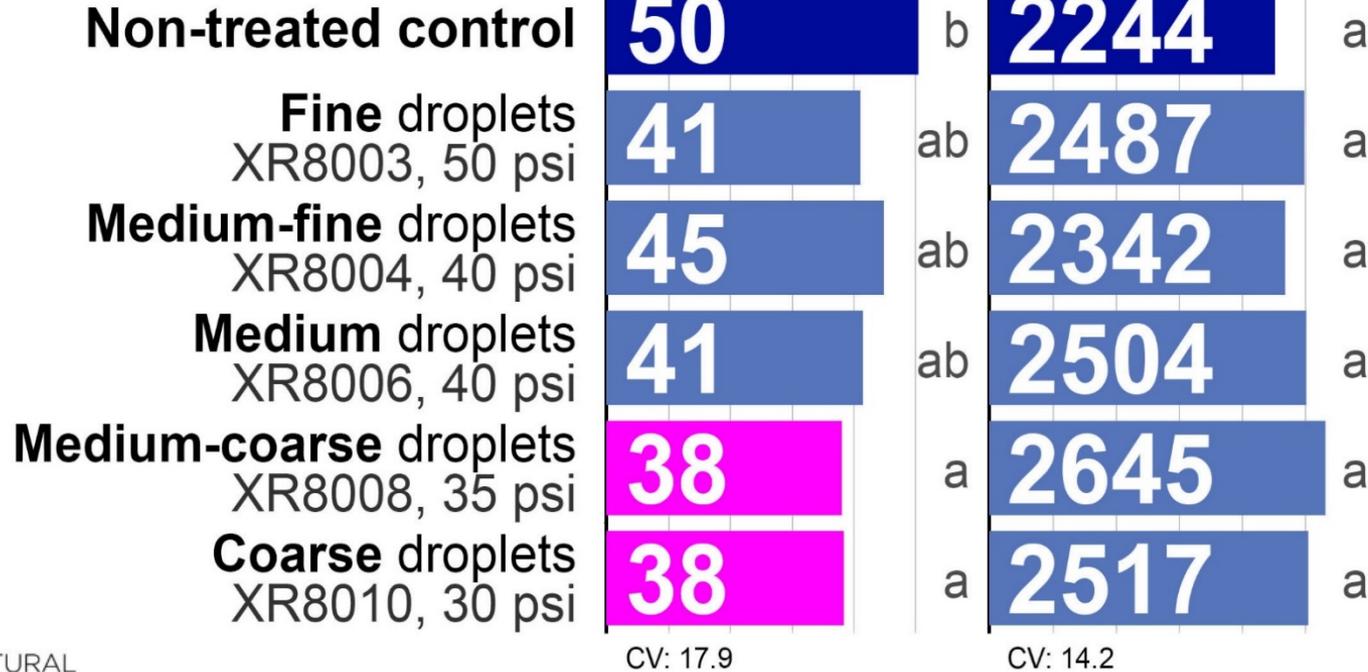
Carrington, ND (2018)  
 'Rosie' light-red kidney  
 21-inch row spacing

TWO FUNGICIDE APPLICATIONS

**White Mold**      **Yield (lbs/ac)**

% canopy diseased

13.5% moisture



**NDSU** NORTH DAKOTA AGRICULTURAL  
 EXPERIMENT STATION



**Spray volume:** 15 gal/ac      **Driving speed:** 6.7 mph

First fungicide application (July 18):  
**Endura 70WG 8 oz/ac**

Full bloom, average pod length 2.5 in. (max. 4.0 in.)  
**canopy closure = 65-75%**, canopy height = 19.5 in.  
 73-80°F, 4-7 mph wind, 55-64% relative humidity

Second fungicide application (Aug. 1):  
**Topsin 4.5FL 40 fl oz/ac**

Full bloom, average 12 full-length pods/plant  
**canopy closure = 100%**, canopy height = 19 inches  
 60-63°F, 8-10 mph wind, 58-70% relative humidity

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Impact of spray droplet size – KIDNEY BEANS

Carrington, ND (2017)

'Rosie' light-red kidney

21-inch row spacing

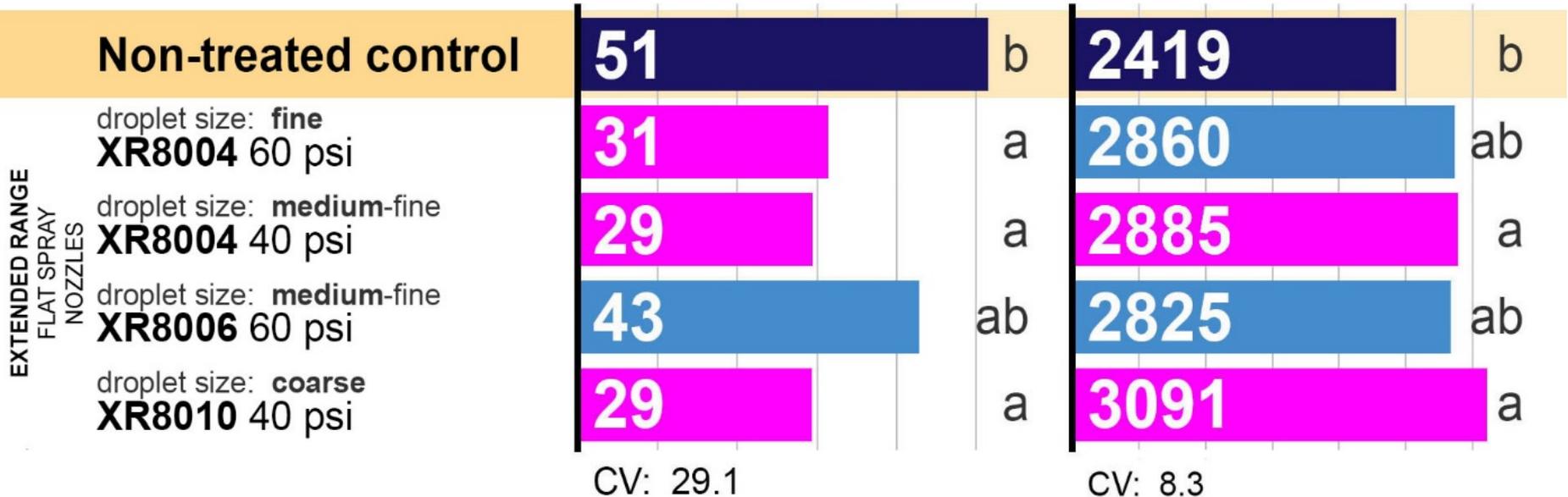
### Sclerotinia stem rot Yield

R7 growth stage

13.5% moisture

Percent of canopy diseased

Pounds/acre



NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

Spray volume: 15 gal/ac Driving speed: 4.0 mph

Fungicide application #1: Topsin 4.5FL 30 fl oz/ac  
(July 10, 10-20% of plants with an open blossom, 30-40% canopy closure)

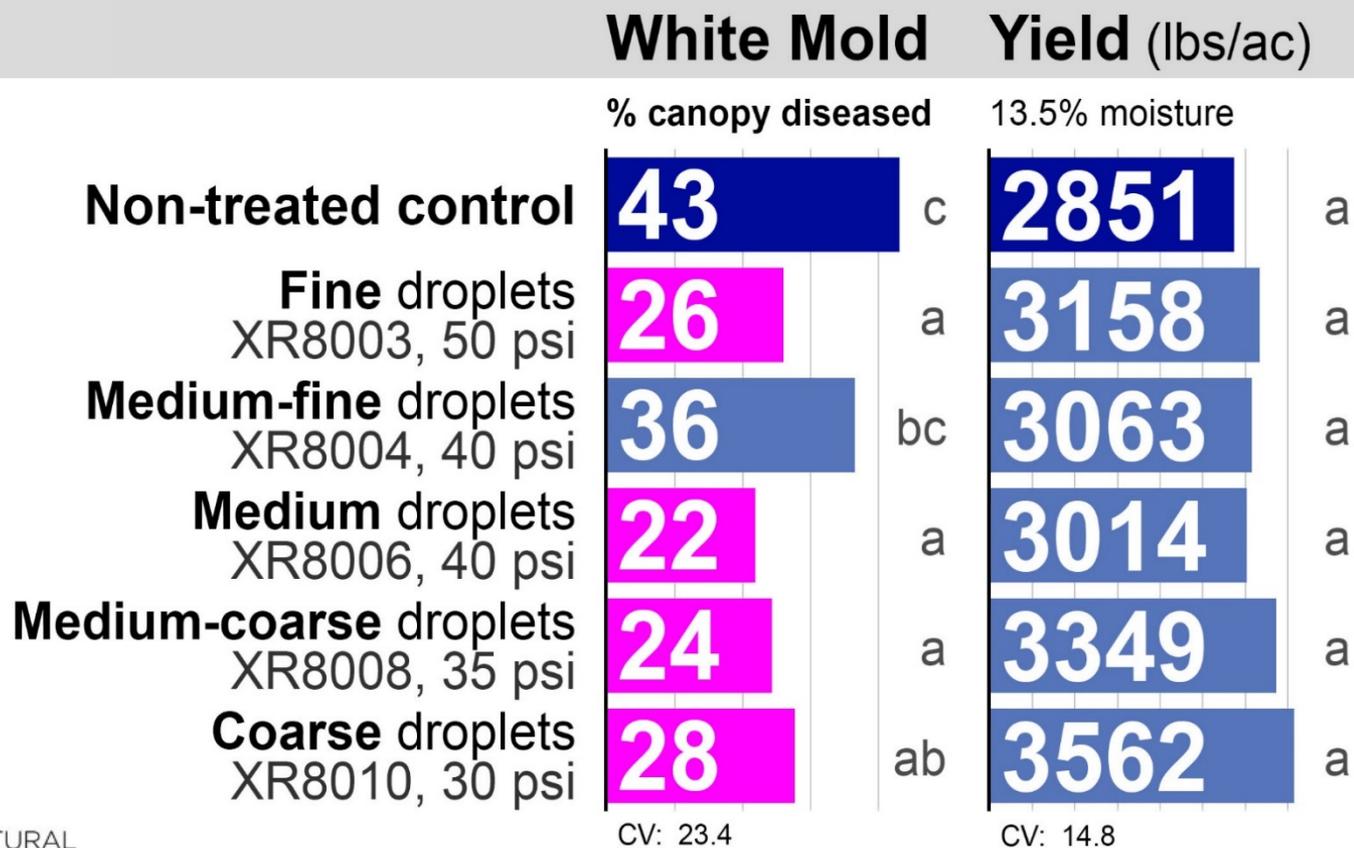
Fungicide application #2: Endura 70WG 8 oz/ac (July 20)

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Impact of spray droplet size – PINTO BEANS

Carrington, ND (2018)  
'Palomino' pinto  
21-inch row spacing

TWO FUNGICIDE APPLICATIONS



**NDSU** NORTH DAKOTA AGRICULTURAL  
EXPERIMENT STATION

**Spray volume:** 15 gal/ac    **Driving speed:** 6.7 mph

First fungicide application (July 5):  
**Topsin 4.5FL 40 fl oz/ac**

100% plants with an open blossom, pin-pods  
canopy closure = 75-80%, canopy height = 19 inches  
69-70°F, 3-5 mph wind, 62-66% relative humidity

Second fungicide application (July 18):  
**Endura 70WG 8 oz/ac**

Full bloom, average pod length = 3 in. (max. = 5 in.)  
canopy closure = 92-98%, canopy height = 19 inches  
73-80°F, 4-7 mph wind, 55-64% relative humidity



# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Impact of spray droplet size – PINTO BEANS

Carrington, ND (2018)  
'Palomino' pinto  
21-inch row spacing

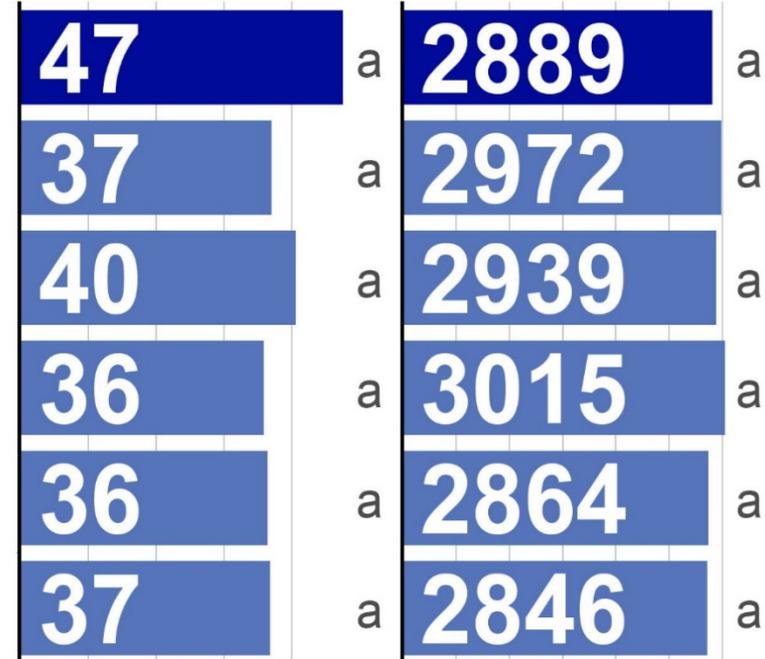
ONE FUNGICIDE APPLICATION

**White Mold**      **Yield (lbs/ac)**

% canopy diseased

13.5% moisture

**Non-treated control**  
**Fine droplets**  
XR8003, 50 psi  
**Medium-fine droplets**  
XR8004, 40 psi  
**Medium droplets**  
XR8006, 40 psi  
**Medium-coarse droplets**  
XR8008, 35 psi  
**Coarse droplets**  
XR8010, 30 psi



CV: 25.1

CV: 12.3

**NDSU** NORTH DAKOTA AGRICULTURAL  
EXPERIMENT STATION



**Spray volume:** 15 gal/ac      **Driving speed:** 6.7 mph

**Fungicide application (July 5):**

**Topsin 4.5FL 40 fl oz/ac**

100% plants with an open blossom, pin-pods  
canopy closure = 75-80%, canopy height = 19 inches  
69-70°F, 3-5 mph wind, 62-66% relative humidity

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Impact of spray droplet size – PINTO BEANS

Carrington, ND (2017)

'Palomino' pinto

21-inch row spacing

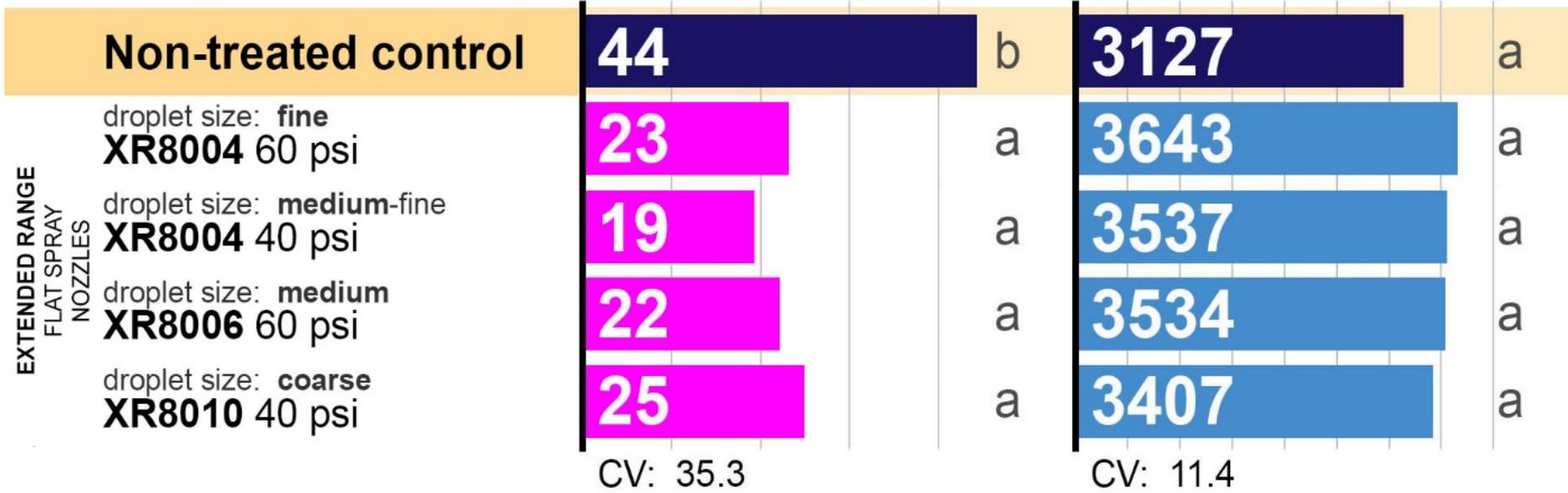
### Sclerotinia stem rot Yield

R7 growth stage

13.5% moisture

Percent of canopy diseased

Pounds/acre



**Spray volume:** 15 gal/ac    **Driving speed:** 4.0 mph

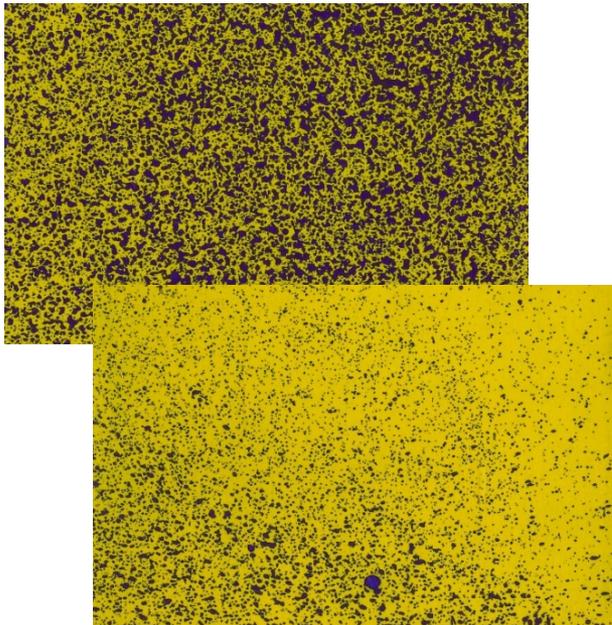
**Fungicide application #1:** Topsin 4.5FL 30 fl oz/ac  
(July 10, 10-15% of plants with an open blossom, 70-82% canopy closure)

**Fungicide application #2:** Endura 70WG 8 oz/ac (July 20)

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN A CROP CANOPY

## Experimental methods – parallel studies in soybeans

**Spray cards** were utilized to confirm that pulse width calibration was correct and that spray volume was consistent across treatments.



	<b>July 13</b>	<b>July 16</b>
	ProSeed 'XT60-40' Peterson '17X09N' Dairyland 'DSR-0904'	Peterson '18X06N'
temperature:	86-87°F	71-74°F
relative humidity:	37-42%	43-49%
wind:	1-2 mph	6-8 mph

### Percent spray coverage

SPRAY CARDS placed at height of crop canopy

**XR8003** 50 psi  
FINE DROPLETS

20

a

20

a

**XR8004** 40 psi  
MEDIUM-FINE DROPLETS

18

a

18

a

**XR8006** 40 psi  
MEDIUM DROPLETS

19

a

19

a

**XR8008** 35 psi  
MEDIUM-COARSE DROPLETS

18

a

18

a

**XR8010** 30 psi  
COARSE DROPLETS

19

a

19

a

*P*>*F*: 0.8327  
*CV*: 10.5

0.3446  
24.1

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN SOYBEAN CANOPIES

## Impact of spray droplet size – SOYBEANS (2018)

**Carrington, ND**

variety (maturity rating): ProSeed 'XT60-40' (0.4)

fungicide application date, growth stage: July 13 100% R2

**Carrington, ND**

Peterson '18X06N' (0.6)

July 16 80% R2, 20% R3

**Carrington, ND**

Dairyland 'DSR-0904' (0.9)

July 13 100% R2

**Carrington, ND**

Peterson '17X09N' (0.9)

July 13 100% R2

**Oakes, ND**

Pioneer 'P11A95X' (1.1)

July 12 80% R2, 20% R3

Canopy closure  
at fungicide application:

Canopy closure:  
**75-90%**

Canopy closure:  
**80-95%**

Canopy closure:  
**90-95%**

Canopy closure:  
**90-95%**

Canopy closure:  
**97-100%**

### White mold severity index (% of canopy diseased)

disease assessment: October 28 (R9)

October 6-7 (R9)

October 21-22 (R9)

October 18-20 (R9)

October 2-5 (R9)

**Non-treated control**

**6** b

**14** b

**17** b

**36** a

**39** b

**Fine droplets**

XR8003, 50 psi

**4** ab

**7** a

**16** ab

**34** a

**32** ab

**Medium-fine droplets**

XR8004, 40 psi

**5** b

**6** a

**16** ab

**34** a

**28** ab

**Medium droplets**

XR8006, 40 psi

**2** a

**5** a

**11** ab

**31** a

**30** ab

**Medium-coarse droplets**

XR8008, 35 psi

**4** ab

**7** a

**10** ab

**31** a

**29** ab

**Coarse droplets**

XR8010, 30 psi

**4** ab

**7** a

**9** a

**26** a

**25** a

CV: 21.8

CV: 52.1

CV: 39.5

CV: 28.1

CV: 21.6



**Fungicide:** Endura at 5.5 oz/ac

**Spray volume:** 15 gal/ac

**Driving speed:** 6.7 mph

**Soybean row spacing:** 21 inches

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN SOYBEAN CANOPIES

## Impact of spray droplet size – SOYBEANS (2018)

**Carrington, ND**

variety (maturity rating): ProSeed 'XT60-40' (0.4)

fungicide application date, growth stage: July 13 100% R2

**Carrington, ND**

Peterson '18X06N' (0.6)

July 16 80% R2, 20% R3

**Carrington, ND**

Dairyland 'DSR-0904' (0.9)

July 13 100% R2

**Carrington, ND**

Peterson '17X09N' (0.9)

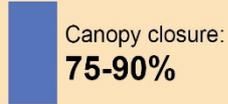
July 13 100% R2

**Oakes, ND**

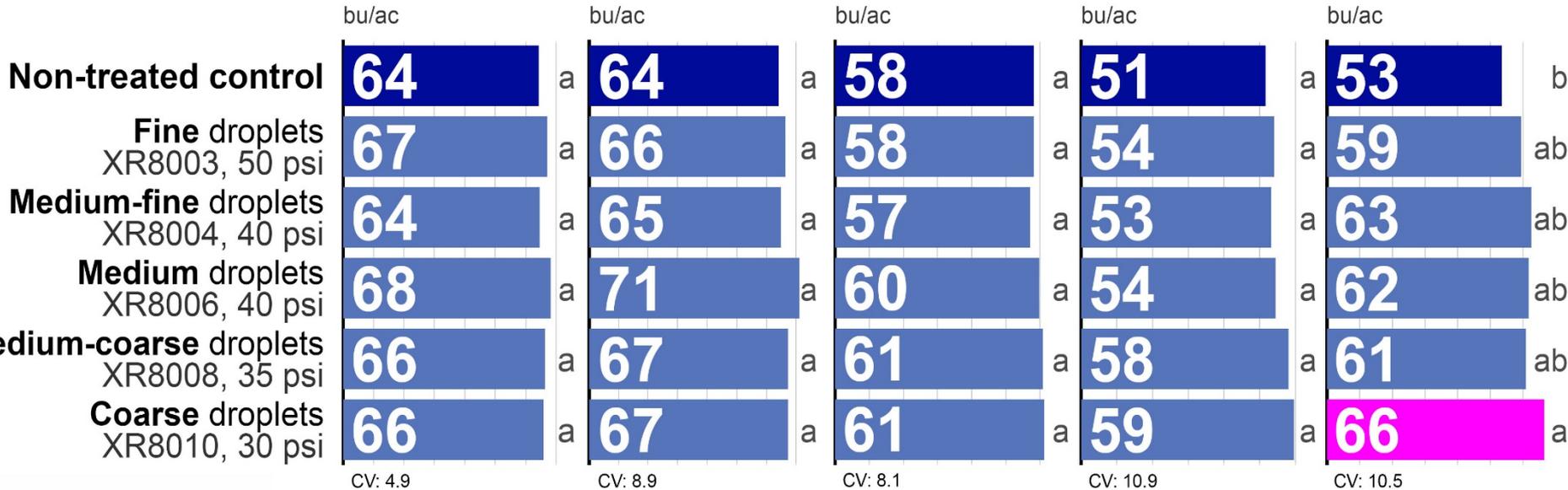
Pioneer 'P11A95X' (1.1)

July 12 80% R2, 20% R3

Canopy closure  
at fungicide application:



### Soybean yield (13% moisture)



**Fungicide:** Endura at 5.5 oz/ac  
**Spray volume:** 15 gal/ac      **Driving speed:** 6.7 mph  
**Soybean row spacing:** 21 inches

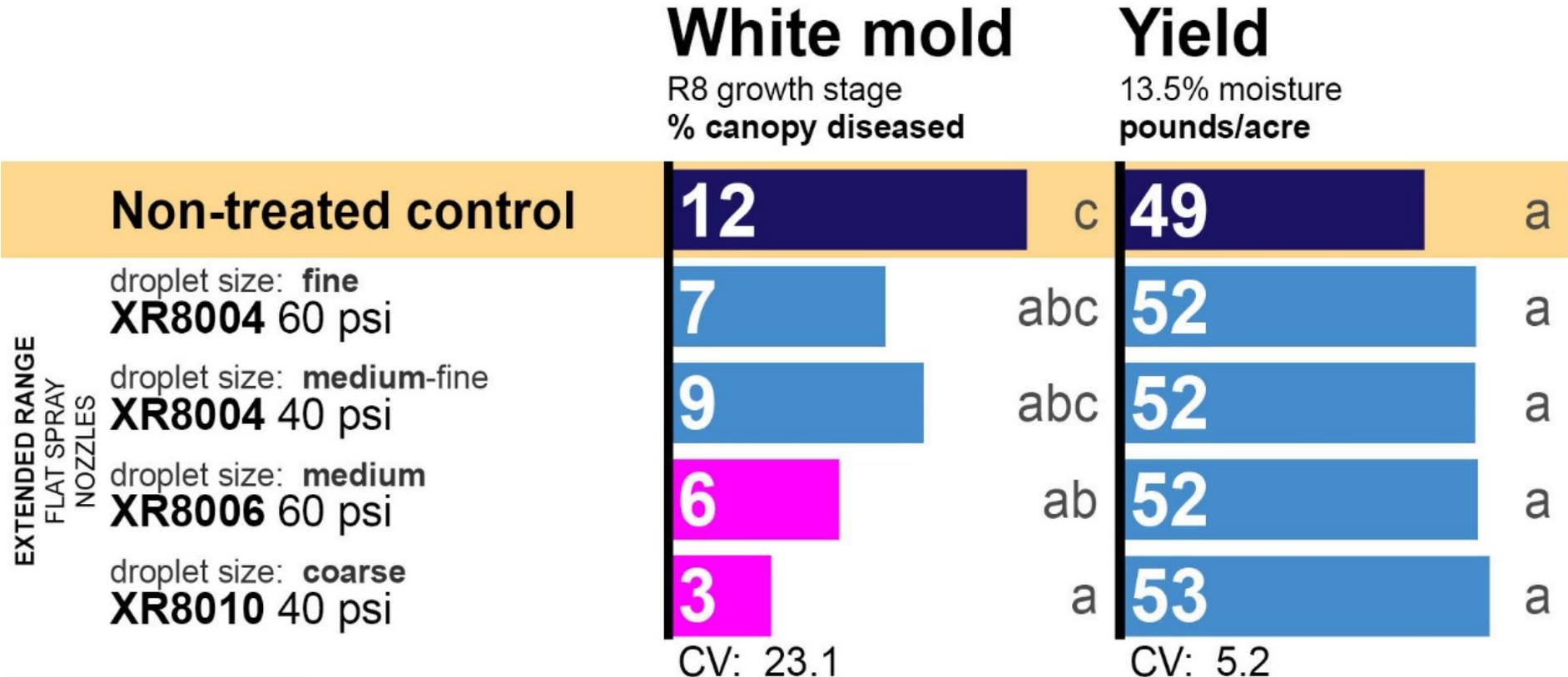
# OPTIMIZING FUNGICIDE DEPOSITION WITHIN SOYBEAN CANOPIES

## Impact of spray droplet size – SOYBEANS (2017)

Carrington, ND (2017)

Dairyland 'DSR-0619' soybean (0.6 maturity)

21-inch row spacing



**Spray volume:** 15 gal/ac      **Driving speed:** 4.0 mph  
**Fungicide:** Endura at 5.5 oz/ac  
**Application timing:** 80% of plants at R2, 20% of plants at R3 growth stage  
Canopy closure (average) = 92%

## Drop nozzles - methods

- **'360' Undercover drop nozzles (360 Yield Center)**
- **Constant driving speed (3.8 mph), spray volume (15 gal/ac)**
- **Drop nozzles centered between 21-inch rows**

Applications were made with a tractor-mounted boom equipped with a pulse-width modulation system (Capstan AG). Pulse width was calibrated and confirmed by measuring nozzle output. Spraying Systems TeeJet spray nozzles were used.



## OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

Drop nozzles – kidney beans, August 1, 2018 (Carrington)



# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Drop nozzles – kidney beans

Carrington, ND (2018)

'Rosie' light-red kidney

21-inch row spacing

DROP NOZZLES

**Non-treated control**

**Boom-mounted nozzles**  
XR8006, 50 psi (medium droplets)

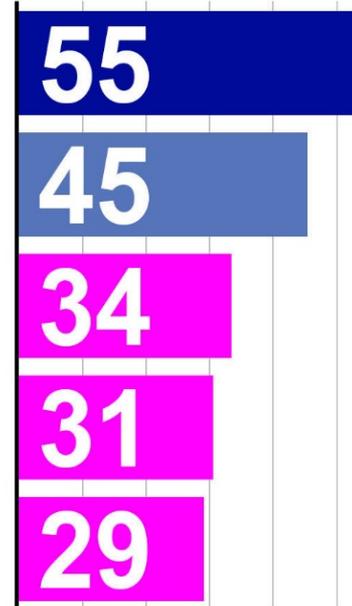
**Very fine droplets**  
TJ60-11002 (side ports), 40 psi

**Fine droplets**  
XR11001 (side) + TX-VK3 (lower rear), 40 psi

**Fine droplets**  
XR11001 (side ports), 40 psi

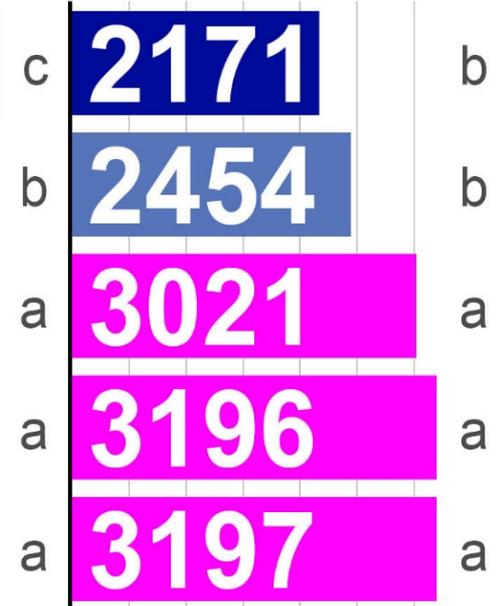
**White Mold**

% canopy diseased



**Yield (lbs/ac)**

13.5% moisture



NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION



**Spray volume:** 15 gal/ac    **Driving speed:** 3.8 mph

First fungicide application (July 18):  
**Endura 70WG 8 oz/ac**

Full bloom, average pod length 1.5 in. (max. 4.0 in.)  
**canopy closure = 75-90%**, canopy height = 19.5 in.  
78-80°F, 6-8 mph wind, 69-73% relative humidity

Second fungicide application (Aug. 1):  
**Topsin 4.5FL 40 fl oz/ac**

Full bloom, average 12 full-length pods/plant  
**canopy closure = 100%**, canopy height = 19 inches  
65°F, 3-6 mph wind, 54-55% relative humidity

# OPTIMIZING FUNGICIDE DEPOSITION WITHIN DRY BEAN CANOPIES

## Drop nozzles – kidney beans

Carrington, ND (2017)

'Rosie' light-red kidney

21-inch row spacing

BOOM-MOUNTED NOZZLES



NDSU NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

**Non-treated control**

**Fine droplets**

XR8004 (flat fan), 60 psi

**Medium-fine droplets**

TJ60-8005 (twin jet), 40 psi

**Medium-fine droplets**

XR8004 (flat fan), 40 psi

**Medium droplets**

XR8006 (flat fan), 40 psi

**Medium-coarse droplets**

AIXR110015 (flat fan), 40 psi

**Coarse droplets**

XR8010 (flat fan), 40 psi

**Drop nozzles - fine droplets**

XR11001 (side ports) + TX-VK6 (rear port)

**White Mold**

% canopy diseased

**Yield (lbs/ac)**

13.5% moisture



CV: 29.1

CV: 8.3

**Spray volume:** 15 gal/ac

**Driving speed:** 4 mph  
except AIXR nozzles (3.2 mph)

First fungicide application (July 10)

**Topsin 4.5FL 30 fl oz/ac**

10-20% of plants with an open blossom, no pods  
**canopy closure = 30-40%**, canopy height = 6-12 in.  
78-83°F, 6-9 mph wind, 41-49% relative humidity

Second fungicide application (July 20)

**Endura 70WG 8.0 oz/ac**

75-86°F, 7-9 mph wind, 53-65% relative humidity



Thank you!

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**Research Funding:**

Northharvest Bean Growers Association

North Dakota Soybean Council

North Dakota Crop Protection Product Harmonization Board & Registration Board