



Improving management of white mold in dry beans: Optimizing fungicide timing, interval, and frequency

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Optimizing fungicide application timing

Research question tested in these studies:

when should fungicides be applied

**when soil moisture and canopy wetness are high-risk
for white mold as dry beans enter bloom?**

If conditions do not favor white mold as dry beans enter bloom, applications should be delayed until weather becomes favorable for white mold.

Optimizing fungicide application timing: **pinto beans**

(1) Pinto beans with an open canopy:

Average canopy closure < 95% at 70-85% plants with initial pods

Combined analysis across 5 studies

Carrington (2021)
cv. 'Palomino'
Topsin 40 fl oz f.b. Endura 8 oz

Oakes (2021)
cv. 'Palomino'
Topsin 40 fl oz f.b. Endura 8 oz

Carrington (2020)
cv. 'Lariat'
Topsin 30 fl oz f.b. Endura 8 oz

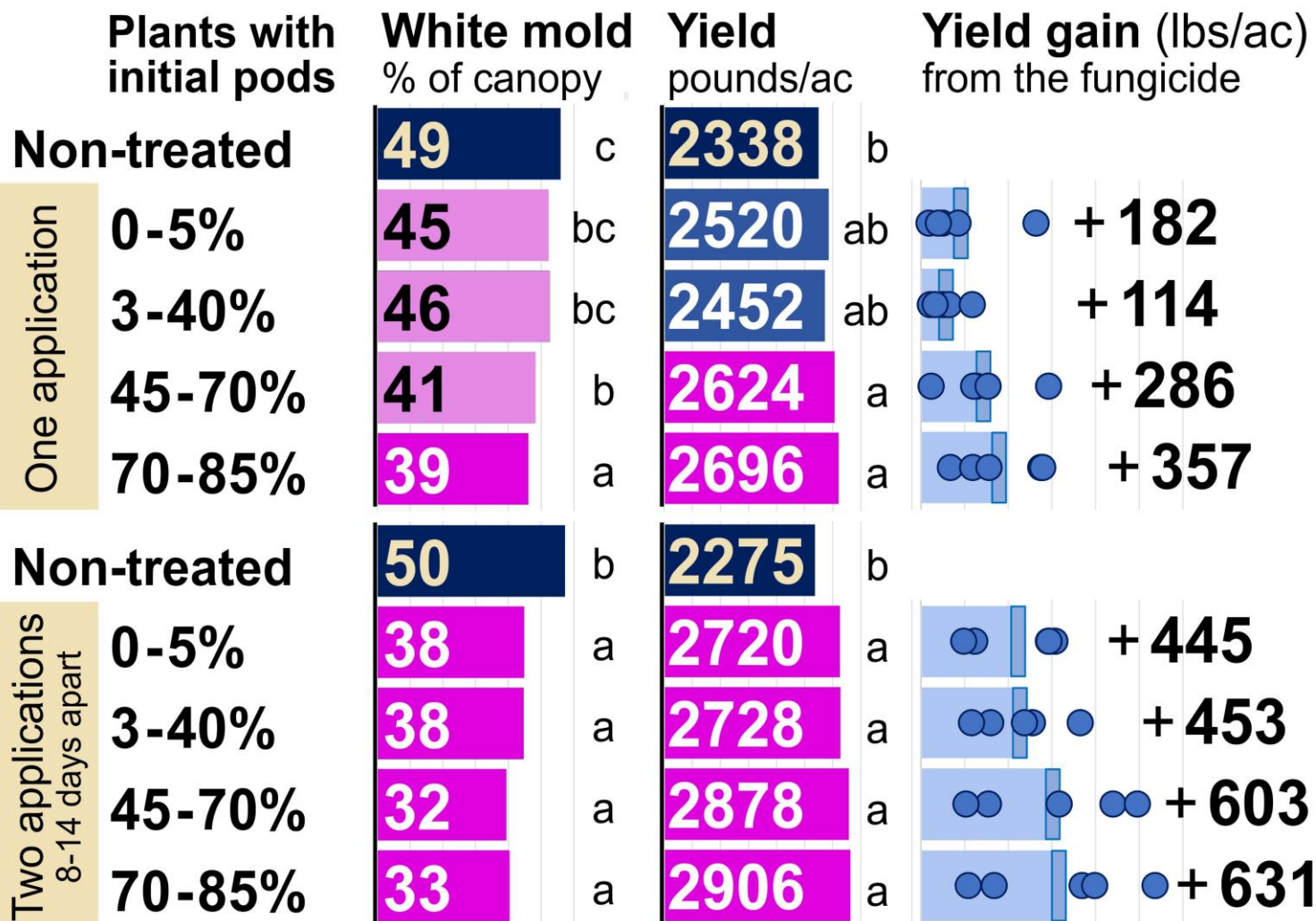
Carrington (2022)
cv. 'Palomino'
Topsin 40 fl oz f.b. Endura 8 oz

Carrington (2024)
cv. 'Torreon'
Endura 8 oz f.b. Endura 8 oz

Row spacing = 14".
Seeding rate = 90,000 viable
seeds/ac.

Spray droplet size calibrated
relative to canopy closure.
Spray volume = 15 gal/ac.

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

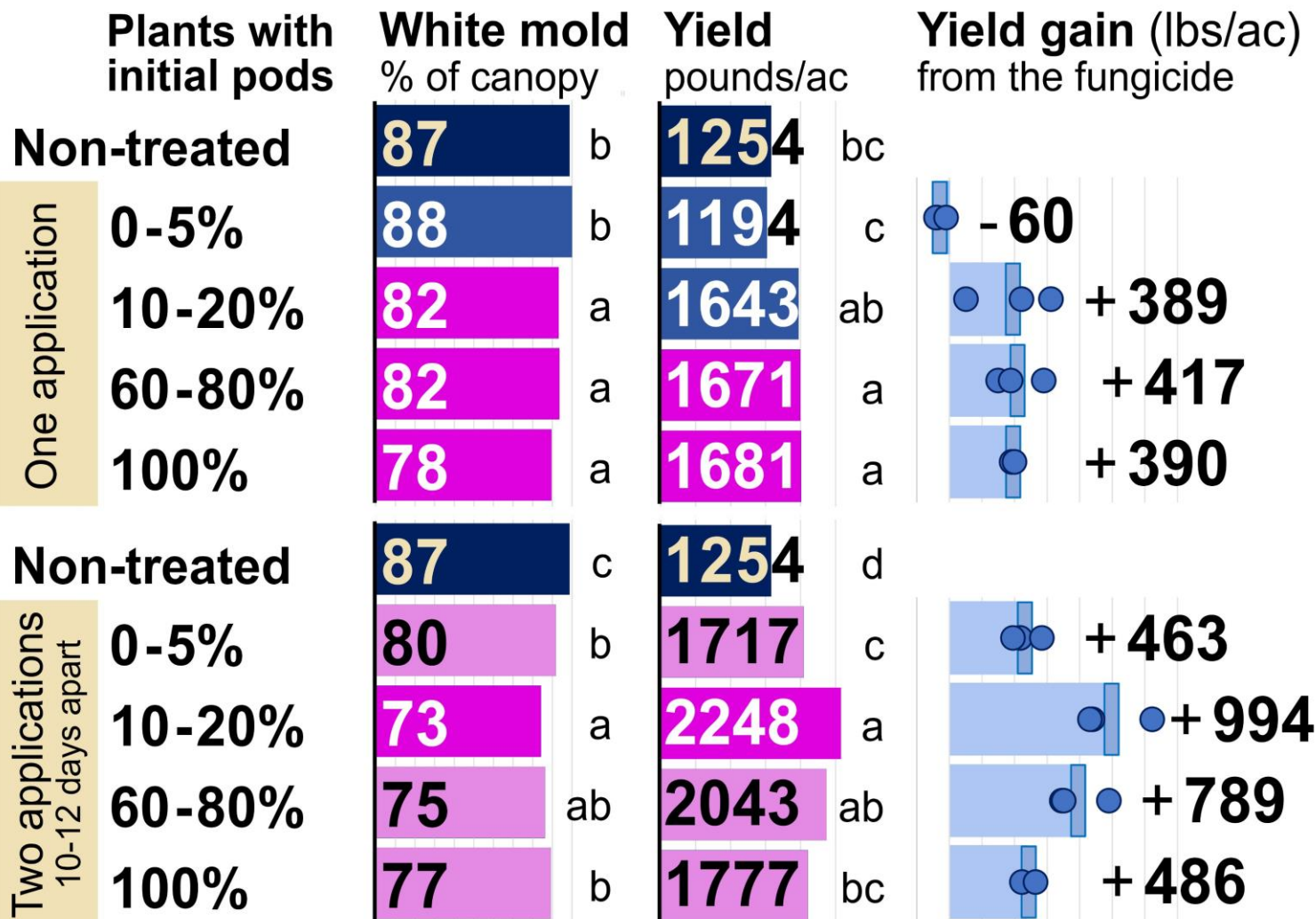


Optimizing fungicide application timing: **pinto beans**

(2) Pinto beans with a closed canopy:

Average canopy closure > 95% at 10-20% plants with initial pods

Combined analysis
across 3 studies



Carrington (2017)
cv. 'La Paz'
Row spacing = 14".
Topsin 30 fl oz f.b. Endura 8 oz

Oakes (2017)
cv. 'LaPaz'
Row spacing = 28".
Topsin 30 fl oz f.b. Endura 8 oz

Carrington (2022)
cv. 'Lariat'
Row spacing = 14".
Topsin 40 fl oz f.b. Endura 8 oz

Seeding rate = 90,000 viable
seeds/ac.

Spray droplet size calibrated
relative to canopy closure.
Spray volume = 15 gal/ac.

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

Optimizing fungicide application timing: pinto beans

(1) Single fungicide application – pinto beans

fungicide efficacy was optimized when applications were made when **60-80% of plants had initial pods** irrespective of canopy closure.

(2) Two fungicide application sequence – pinto beans

fungicide efficacy was optimized when the first application was made when approx. **50-80% of plants had initial pods** (when the canopy was open) or **10-20% of plants had initial pods** (when canopy was at or near closure when 10-20% of plants had initial pods).

Penalty to applying too late:

Fungicide applications must be made prior to pathogen infection.

- You cannot eradicate existing disease.
- Some, but not all, modern fungicides exhibit some degree of curative activity, but this curative activity is limited to the first few hours after pathogen infection – when pathogen infection can be seen only with a microscope and before disease lesions are present.

Fungicide application timing – fundamental concepts

Penalty to applying too early:

New growth is not protected by the fungicide.

- Only the biomass that exists at the time that the fungicide is applied is protected.
- This is a problem for white mold management because dry beans exhibit significant growth during early bloom.
- Dry beans increase in susceptibility to white mold as the percent of plants with initial pods (= % of plants with dead blossoms) increases

Improving crop disease management: Fungicide application timing – fundamental concepts

New growth is not protected by the fungicide.

- Example from field peas
- These peas were treated with a fungicide at bloom initiation
- Growth that occurred after bloom initiation was unprotected and became diseased with powdery mildew.
 - This is why (in the picture at the right) the upper ~ 1/5 of the canopy is diseased and the lower ~ 4/5 of the canopy is healthy.

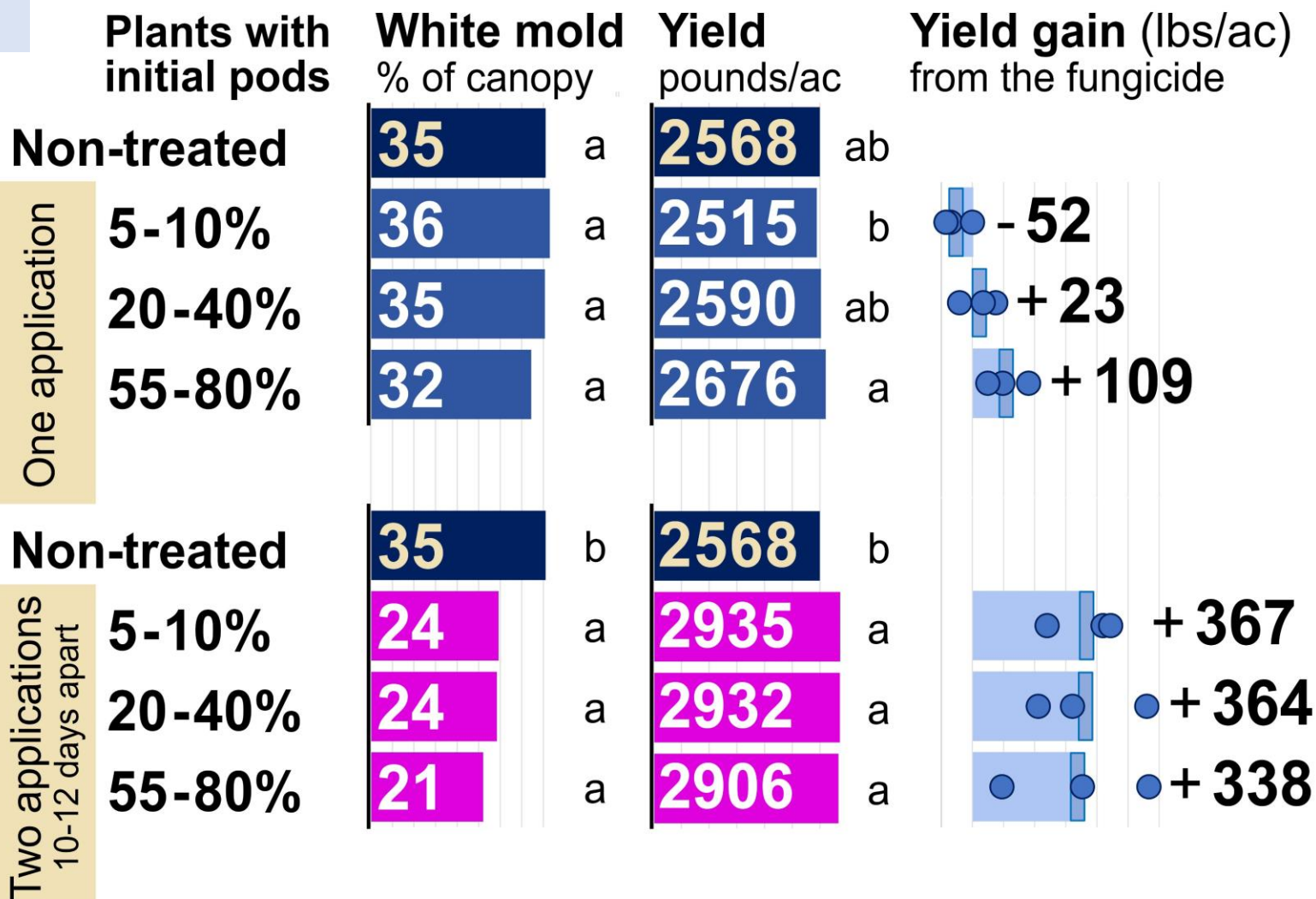


Optimizing fungicide application timing: **kidney beans**

(1) Studies in which early application timing was assessed:

Average canopy closure < 95% through 50% plants with initial pods

Combined analysis
across 3 studies



Carrington (2020)
cv. 'Dynasty' DR Kidney
Topsin 30 fl oz f.b.
Endura 8 oz

Carrington (2021)
cv. 'Dynasty' DR Kidney
Topsin 40 fl oz f.b.
Endura 8 oz

Carrington (2022)
cv. 'Red Hawk' DR Kidney
Topsin 40 fl oz f.b.
Endura 8 oz

Row spacing = 14".
Seeding rate = 90,000
viable seeds/ac.

Spray droplet size
calibrated relative to canopy
closure.
Spray volume = 15 gal/ac.

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

Optimizing fungicide application timing: **kidney beans**

(2) Studies in which late application timing was assessed:

Average canopy closure < 95% through 80-95% plants with initial pods

Combined analysis
across 3 studies

Plants with
initial pods

White mold
% of canopy

Yield
pounds/ac

Yield gain (lbs/ac)
from the fungicide

Non-treated

One application

20-40%

29 a

3084 a

+ 99

60-80%

23 a

3183 a

+ 85

80-95%

23 a

3169 a

+ 210

85-100%

21 a

3294 a

+ 134

Non-treated

Two applications
11-14 days apart

20-40%

29 b

2991 b

+ 424

60-80%

18 a

3415 a

+ 308

80-95%

18 a

3299 a

+ 309

85-100%

18 a

3300 a

+ 319

Carrington (2021)
cv. 'Dynasty' DR Kidney
Topsin 40 fl oz f.b.
Endura 8 oz

Carrington (2022)
'Pink Panther' LR Kidney
Topsin 40 fl oz f.b.
Endura 8 oz

Carrington (2024)
'Pink Panther' LR Kidney
Endura 8 oz f.b.
Endura 8 oz

Row spacing = 14".
Seeding rate = 90,000
viable seeds/ac.

Spray droplet size
calibrated relative to canopy
closure.
Spray volume = 15 gal/ac.

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

Optimizing fungicide application timing: **kidney beans**

(1) Single fungicide application – kidney beans

fungicide efficacy was optimized when applications were made when approx. **80% of plants had initial pods**.

The canopy was open in all of the studies in which application timing was tested (<95% closure through 50% of plants with initial pods).

(2) Two fungicide application sequence – kidney beans

fungicide efficacy was optimized when the first application was made when approx. **20% of plants had initial pods**.

The canopy was open in all of the studies in which application timing was tested (<95% closure through 50% of plants with initial pods).

Optimizing fungicide application timing: **navy beans**

(1) **Navy beans:** studies where canopy was open and daytime high temperatures in mid-upper 80s, low 90s (84-92°F) at initial pod

NAVY

warm temperatures

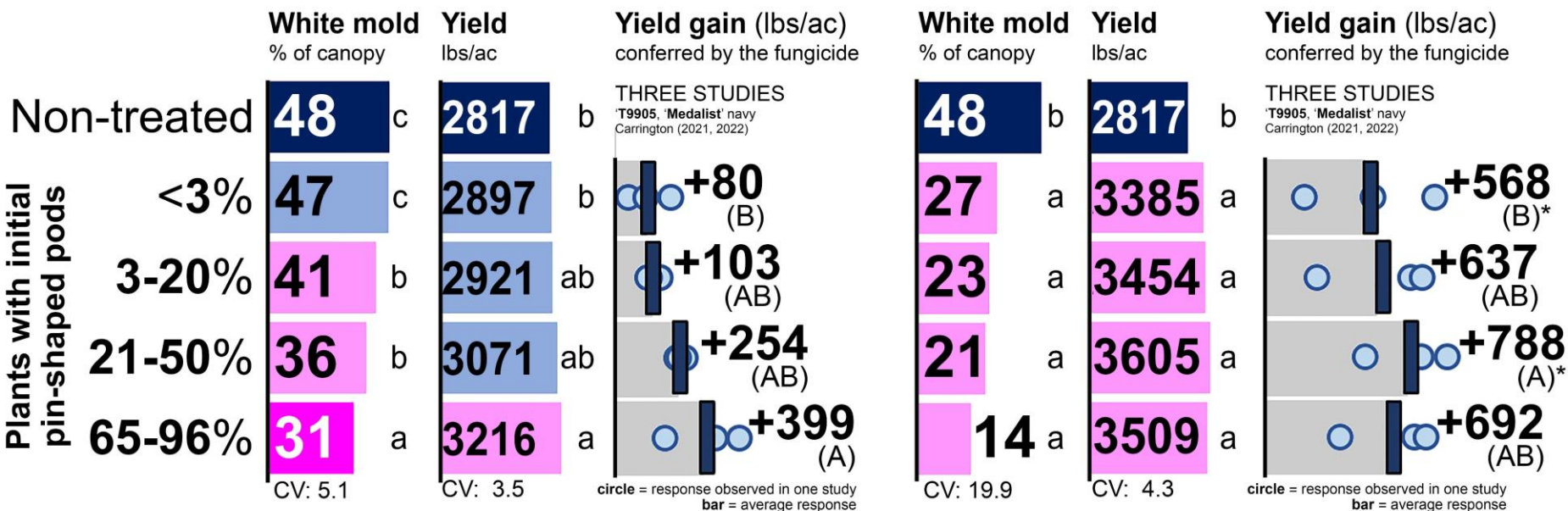
<95% canopy closure when 21-50% of plants had initial pods

average daily high observed between 2nd and 3rd application timing: **88-90°F**

average daily high observed between 3rd and 4th application timing: **84-92°F**

(A) SINGLE FUNGICIDE APPLICATION

(B) TWO APPLICATIONS, 10-14 days apart



'T9905' and 'Medalist' navy beans Carrington, ND (2021, 2022)

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

Topsin (40 fl oz) or Topsin (40 fl oz) followed by Endura (8 oz) 10 or 14 days later

Row spacing = 14" Spray volume = 15 gal/ac.

Optimizing fungicide application timing: **navy beans**

(1) Navy beans: studies where canopy was open and daytime high temperatures in low 80s (79-82°F) at initial pod

NAVY
cool temperatures

<95% canopy closure when 21-50% of plants had initial pods

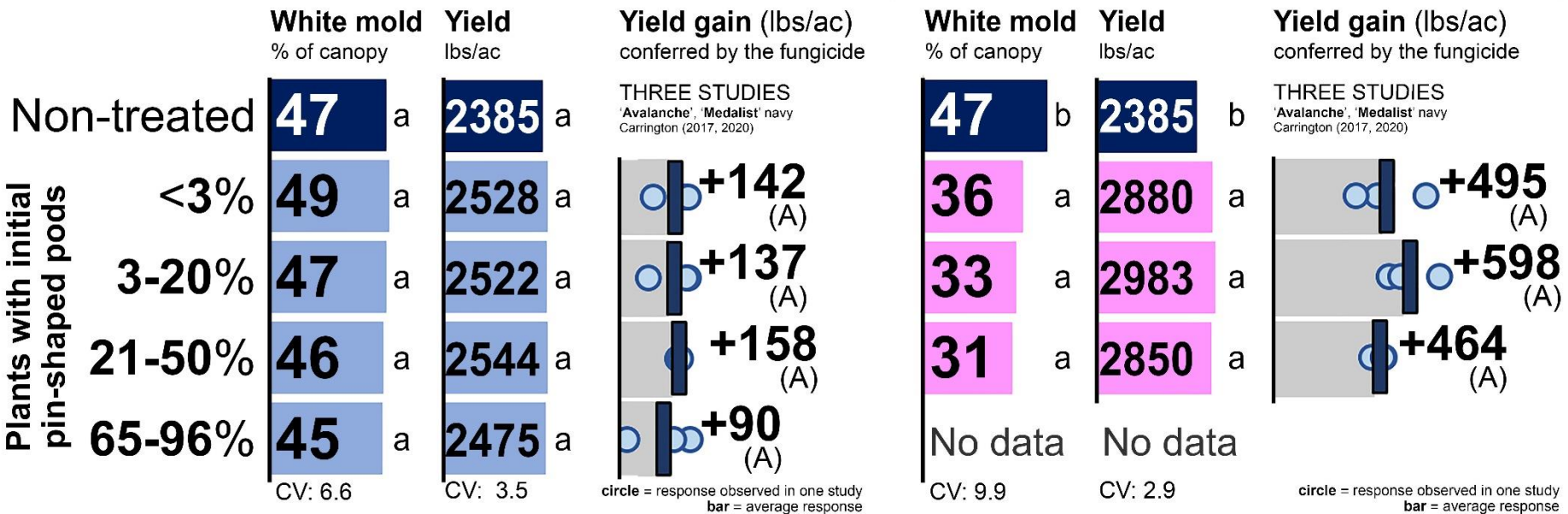
average daily high observed between 2nd and 3rd application timing: **79-80°F**

average daily high observed between 3rd and 4th application timing: **80-82°F**

(A) SINGLE FUNGICIDE APPLICATION

(B) TWO APPLICATIONS, 10-14 days apart

APPLICATION TIMING:
Plants with initial
pin-shaped pods



'Avalanche' and 'Medalist' navy beans Carrington, ND (2017, 2020)

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

Topsin (30 fl oz) or Topsin (30 fl oz) followed by Endura (8 oz) 10-12 days later

Row spacing = 14" or 28". Spray volume = 15 gal/ac.

Optimizing fungicide application timing: **navy beans**

(1) Single fungicide application – navy beans

Optimal application timing was **65-95% of plants with initial pods** when temperatures were high at initial pod (mid to upper 80s°F).

When temperatures in low 80s°F at initial pod, a single fungicide application provided unsatisfactory white mold management.

(2) Two fungicide application sequence – navy beans

Optimal application timing was **3-20% of plants with initial pods** when conditions were cool at initial pod (low 80s°F) and **20-50% of plants with initial pods** when temperatures were high (mid 80s to low 90s°F) at initial pod.

The canopy was open in all of the studies in which application timing was tested (<95% closure through 50% of plants with initial pods).

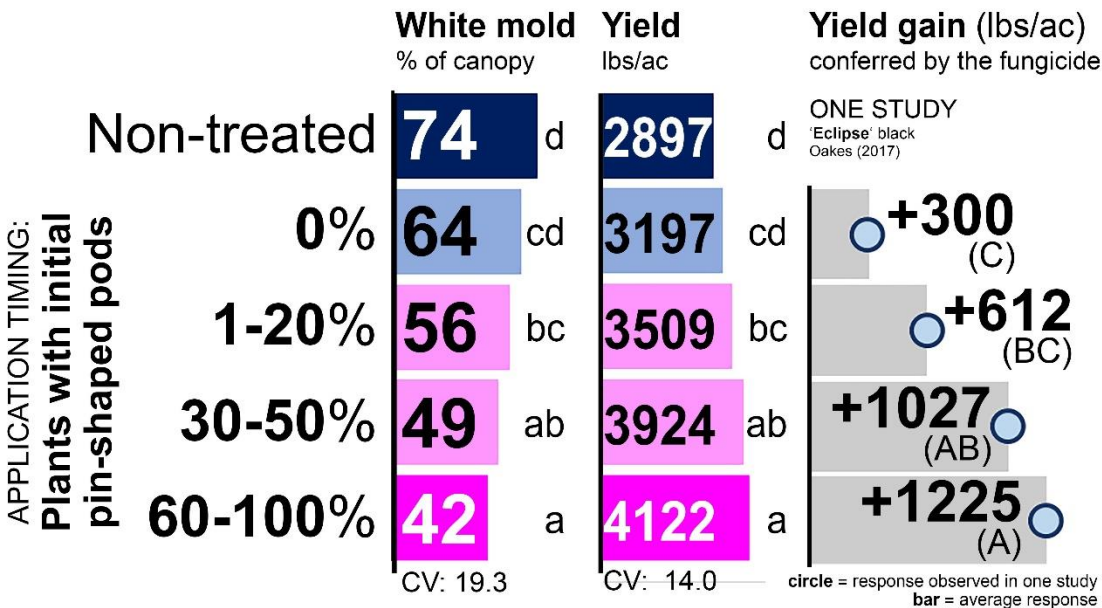
Optimizing fungicide application timing: **black beans**

BLACK BEANS – study where a single application had efficacy.
Closed canopy, cool temperatures at initial pod.

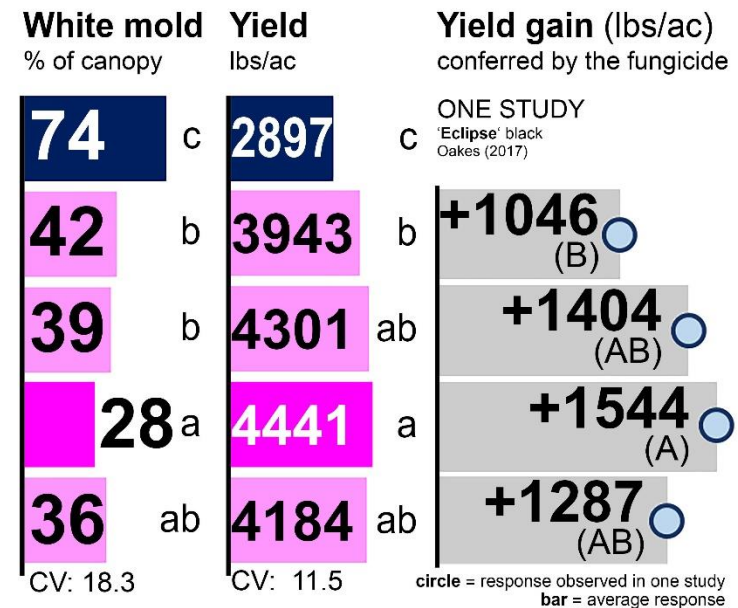
BLACK
canopy at or near
closure

average **88% canopy closure** when 1-20% of plants had initial pods
average **97% canopy closure** when 60-100% of plants had initial pods
average daily high observed between 2nd and 3rd application timing: **79°F**
average daily high observed between 3rd and 4th application timing: **82.5°F**

(A) SINGLE FUNGICIDE APPLICATION



(B) TWO APPLICATIONS, 12 days apart



'Eclipse' black beans Oakes, ND (2017)

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

Topsin (30 fl oz) or Topsin (30 fl oz) followed by Endura (8 oz) 12 days later

Row spacing = 14". Spray volume = 15 gal/ac.

Optimizing fungicide application timing: **black beans**

BLACK BEANS – studies where a single application had no efficacy.
Open canopy, cool temperatures at initial pod.

BLACK
open canopy

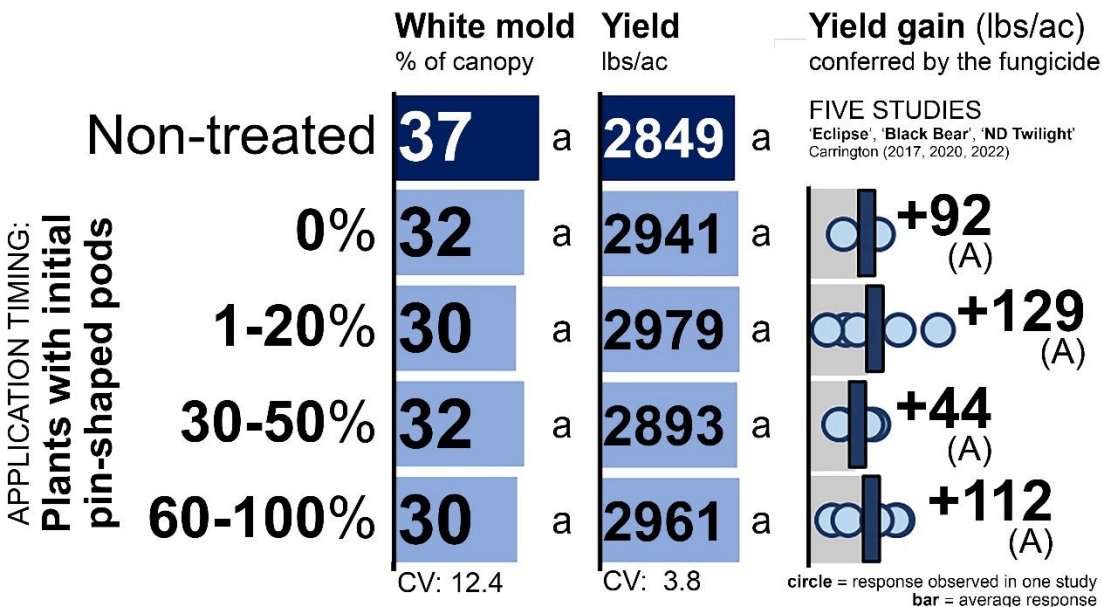
average 60-86% canopy closure when 1-20% of plants had initial pods

average 70-90% canopy closure when 60-100% of plants had initial pods

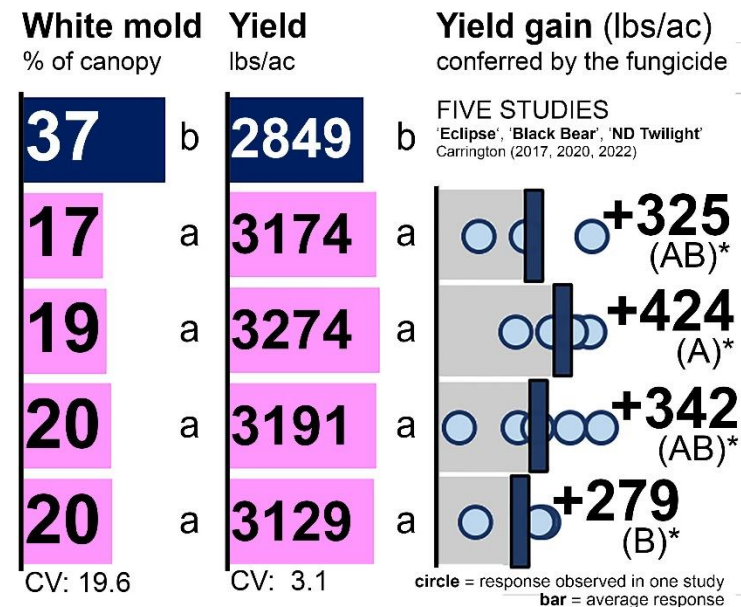
average daily high observed between 2nd and 3rd application timing: 79-80°F

average daily high observed between 3rd and 4th application timing: 80-81.5°F (3 studies), 90°F (2 studies)

(A) SINGLE FUNGICIDE APPLICATION



(B) TWO APPLICATIONS, 10-12 days apart



'Black Bear', 'Eclipse' and 'ND Twilight' black beans Carrington, ND (2017, 2020, 2022)

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

Topsin (30 or 40 fl oz) or Topsin (30 or 40 fl oz) followed by Endura (8 oz) 10-12 days later

Row spacing = 14" or 28". Spray volume = 15 gal/ac.

Optimizing fungicide application timing: **black beans**

(1) Single fungicide application – black beans

A single fungicide application only provided satisfactory management of white mold in 1 of 6 studies.

- Optimal application timing in this study was 90-100% of plants with initial pods

(2) Two fungicide application sequence – black beans

Fungicide efficacy was optimized when the first application was made when **1-30% of plants had initial pods**.

- When conditions are highly favorable for white mold, applications should be targeted for 1-20% of plants with initial pods
- When conditions are less favorable for white mold, applications should be targeted at 20-30% of plants with initial pods

The canopy was open in all of the studies in which application timing was tested (<95% closure through 50% of plants with initial pods).

Optimizing fungicide application timing

When white mold risk is high as dry beans enter bloom (moist soils, recurrent canopy wetting, cool or moderate temperatures,

Optimizing fungicide application in dry beans is difficult

- **Penalty to applying too early**
 - New growth is not protected
- **Penalty to applying too late**
 - Curative activity limited to maximum 24 hours after pathogen infection
- Optimal timing differs for 1 vs. 2 applications
- Optimal timing dependent on weather, canopy closure

Optimizing fungicide application timing

CHALLENGES:

- White mold management not very good even at optimal application timing.
 - Disease rarely reduced by even 50%
- Applying at the perfect timing is very difficult
 - Dry bean growth & development is variable within most fields
 - Not every day is a suitable day for spraying

Optimizing fungicide application timing

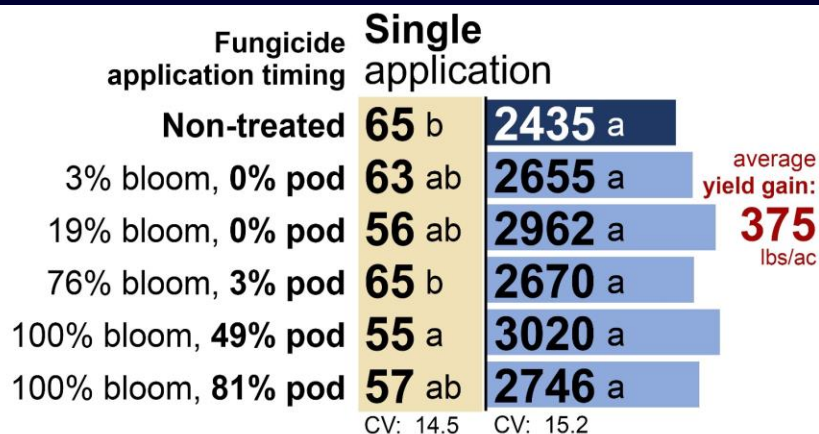
Can we improve fungicide performance by modifying application interval and/or application frequency?

- Reducing the application interval reduces the amount of unprotected new dry bean growth and should reduce the penalty to applying fungicides applying too early
- ... but may require a third fungicide application under high disease pressure

Application methods



Fungicide application timing, interval & frequency: **pinto beans**



'Torreon' pinto
Carrington, ND (2024)

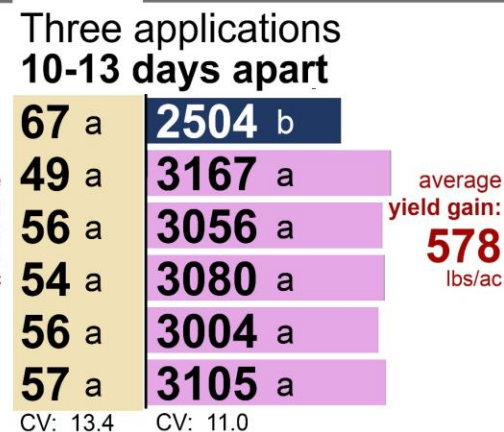
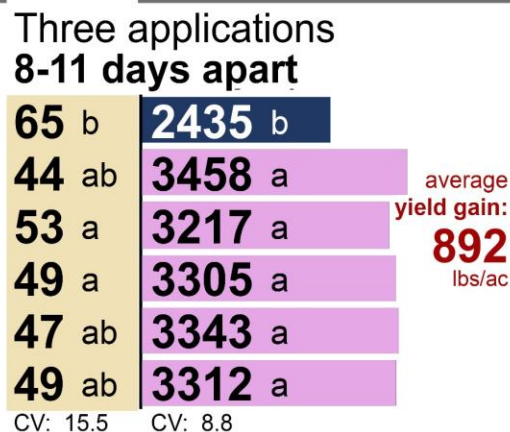
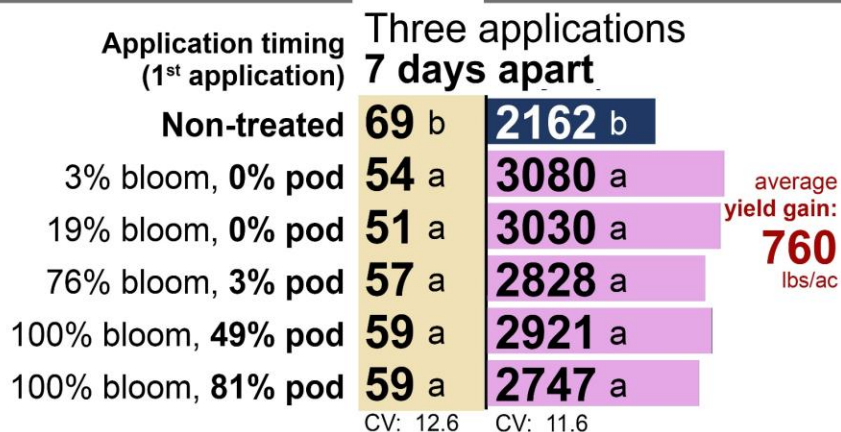
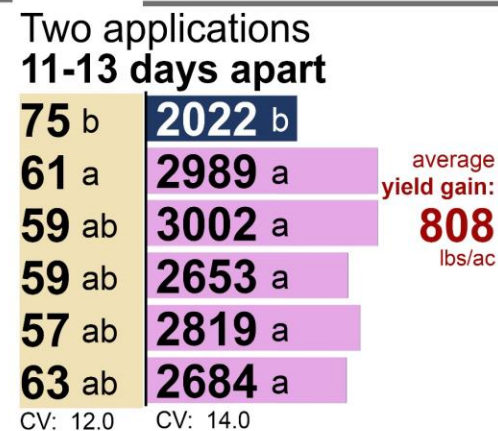
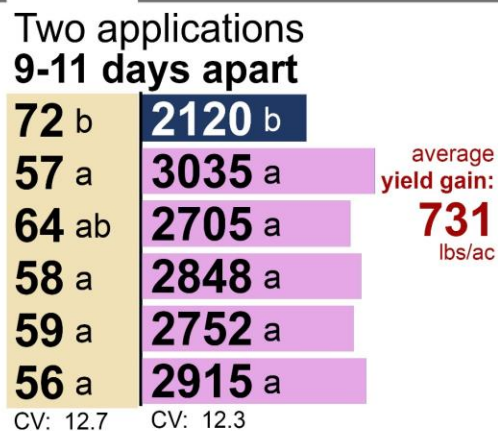
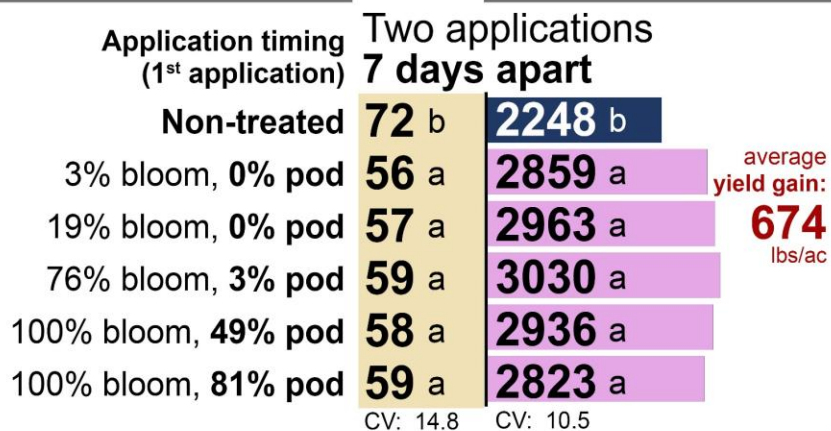
Row spacing = 14"

Seeding rate = 90,000 viable seeds/ac

Endura 8 oz/ac applied once, twice or three times

Spray volume = 15 gal/ac Driving speed = 6 mph

White mold (% of canopy), Yield (lbs/ac)

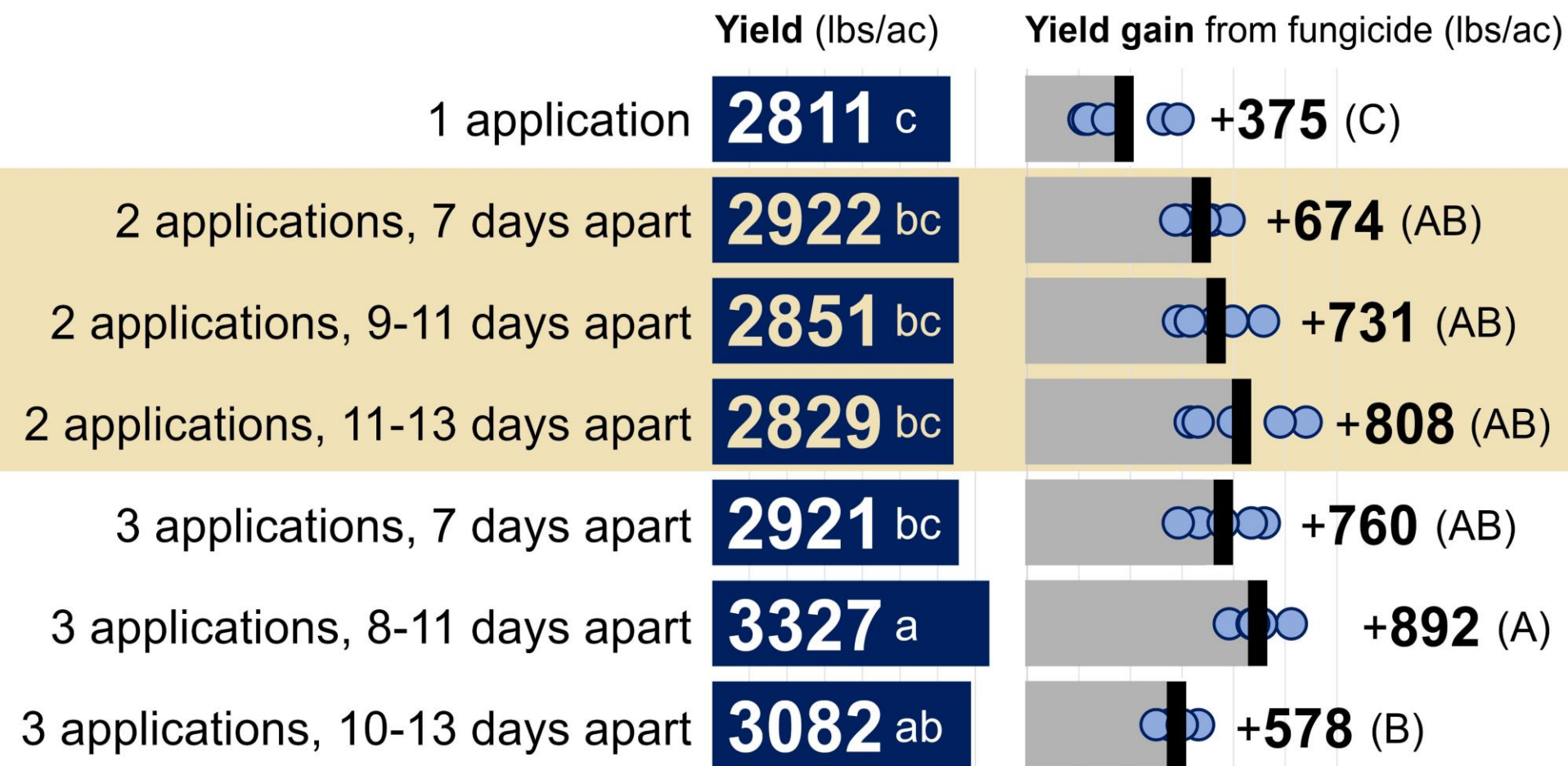


Fungicide application timing, interval & frequency: **pinto beans**

Pinto beans: White mold management was optimized with 3 applications, each approx. 10 days apart.

When making 2 applications, optimal interval was approx. 12 days.

PINTO BEANS (cv. 'Torreón')



Fungicide application timing, interval & frequency: **kidney beans**

'Pink Panther' light-red kidney
Carrington, ND (2024)

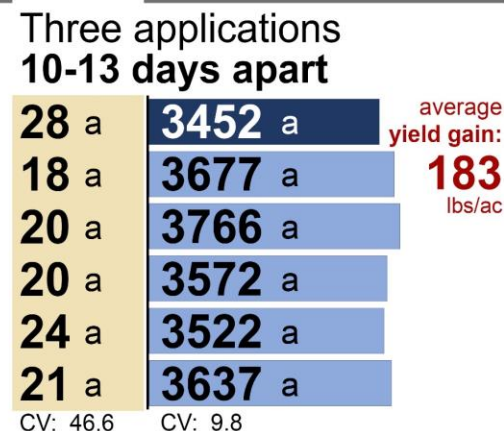
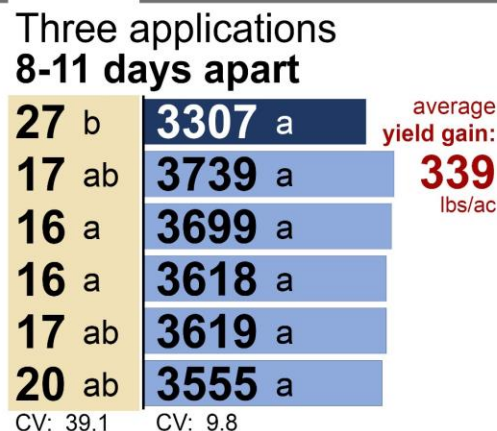
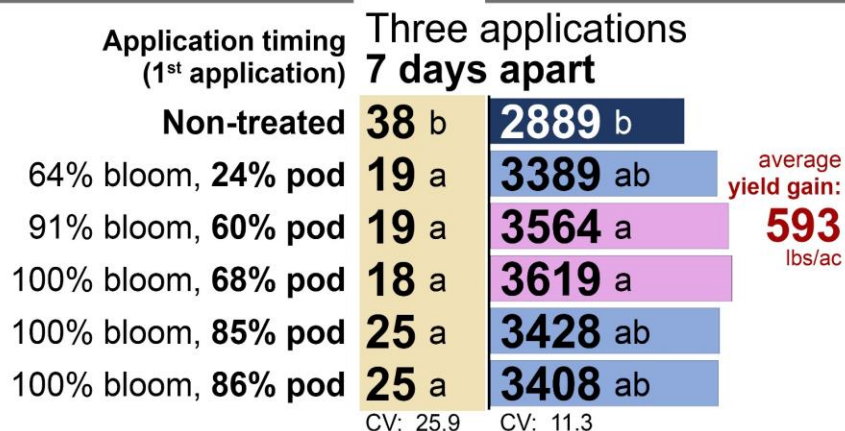
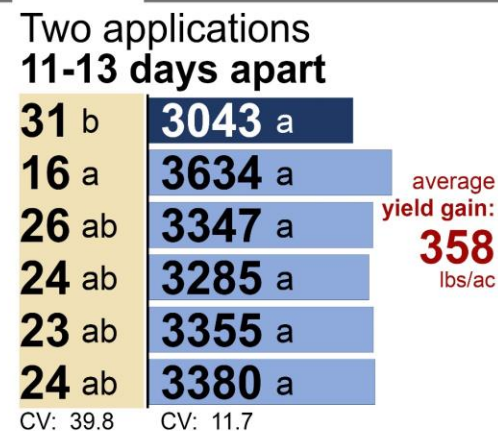
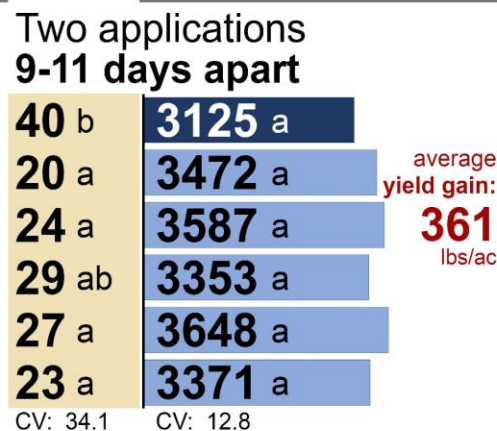
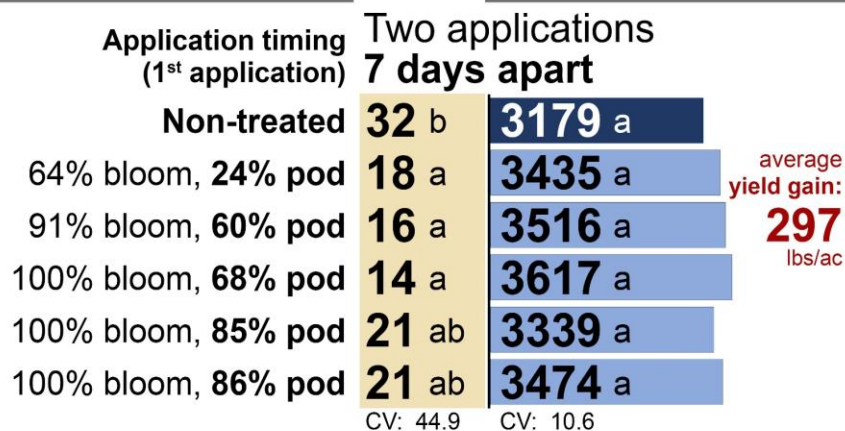
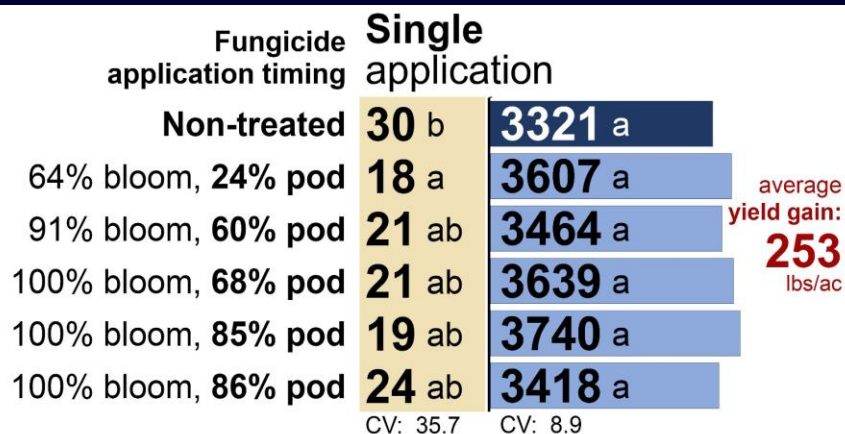
Row spacing = 14"

Seeding rate = 90,000 viable seeds/ac

Endura 8 oz/ac applied once, twice or three times

Spray volume = 15 gal/ac Driving speed = 6 mph

White mold (% of canopy), Yield (lbs/ac)



Fungicide application timing, interval & frequency: **kidney beans**

Kidney beans: White mold management was optimized with 3 applications, each approx. 7 days apart.

When making 2 applications, optimal interval was approx. 10 days.

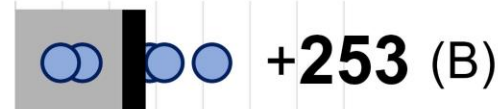
KIDNEY BEANS (cv. 'Pink Panther')

Yield (lbs/ac)

Yield gain from fungicide (lbs/ac)

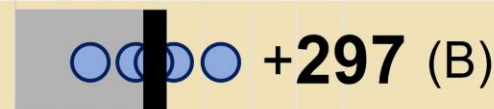
1 application

3574 ab



2 applications, 7 days apart

3476 ab



2 applications, 9-11 days apart

3486 ab



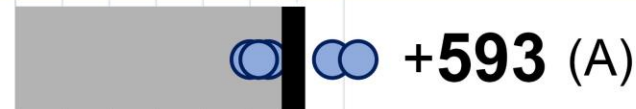
2 applications, 11-13 days apart

3400 b



3 applications, 7 days apart

3482 ab



3 applications, 8-11 days apart

3646 a



3 applications, 10-13 days apart

3635 a





People

Staff, Carrington: Aaron Fauss, Suanne Kallis, Jesse Hafner, Gabriela Henson

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- **Green Valley Bean Company** (John Berthold; Park Rapids, MN)
- **Kelley Bean Company; Hatton, ND** (Dean Nelson)