

Expanding organic dry bean production in the northeastern and upper midwestern US

Exploring agronomic, breeding, and market opportunities

Data compiled by and slides modified from:
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ECOBEAN



Background: Organic dry bean production in the northeast & upper midwest regions

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Dry bean variety comparisons



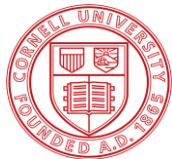
How do different market classes of dry beans fit into tilled vs no-till systems



Optimizing seeding rates of dry beans in no-till conditions



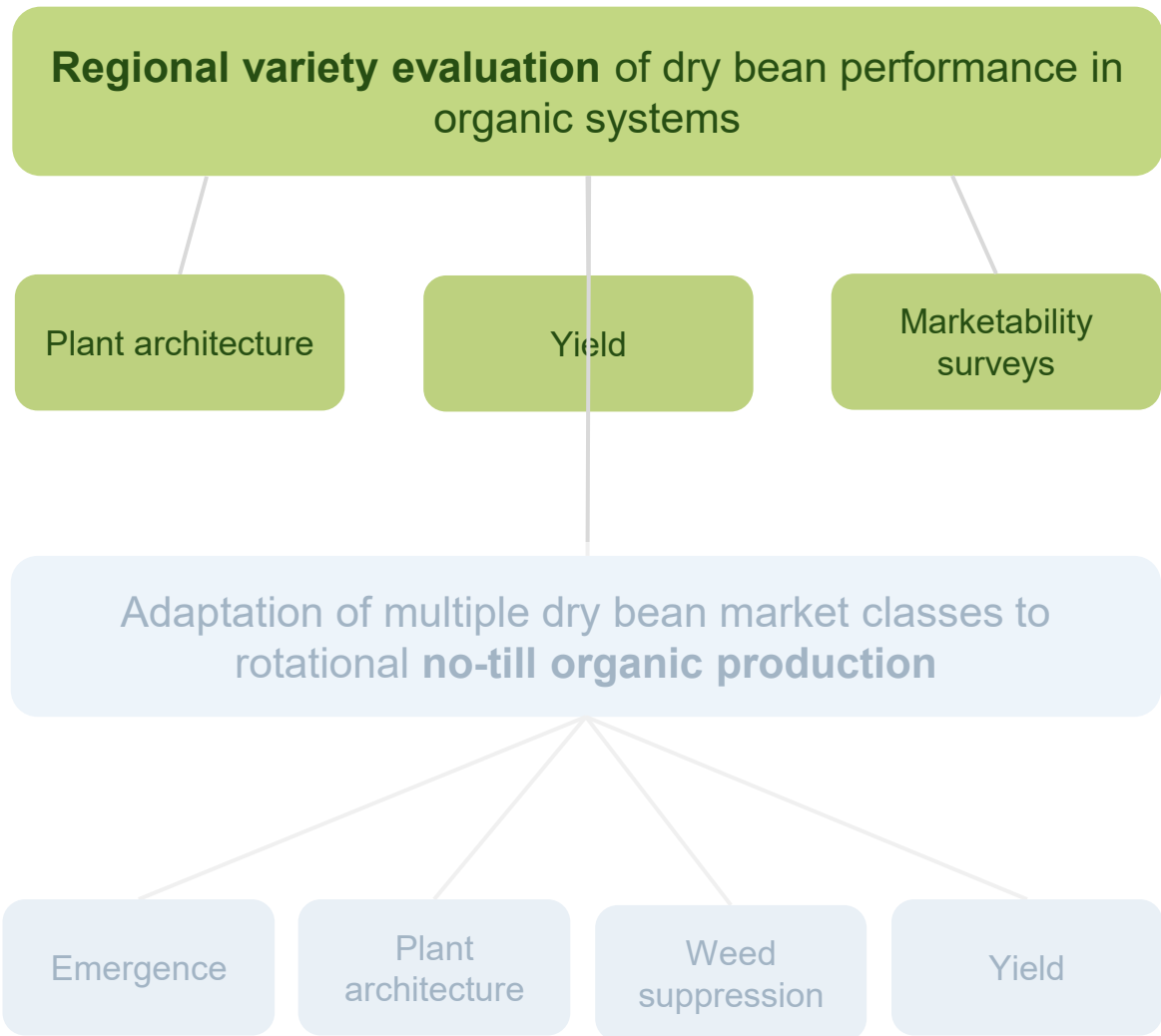
Improving weed management with inter-row mowing



Background: Organic dry bean production in the northeast & upper midwest regions



Expanding **organic**
dry bean production
in the *northeast* &
upper midwest regions



VARIETY EVALUATION

- 32 dry bean varieties compared
- **Yield, pod height, & lodging** evaluated at harvest
- Experiments conducted in NY, VT, WI, & ME from 2023-2024
- Represents 8 individual experimental locations

HYPOTHESIS

Varieties having undergone modern breeding will be higher yielding & better suited to direct harvest.

Black



Pinto



Small red



Navy



Specialty & heirloom



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HYPOTHESIS

Varieties having undergone modern breeding will be higher yielding & better suited to direct harvest.

Black



1. Black Beard
2. Black Tails
3. Eclipse
4. Zenith
5. Zorro

Pinto



1. Charro
2. Cowboy
3. Gleam
4. Lariat
5. Max
6. Monterrey

Small red



1. Cayenne
2. Merlot
3. Rojo Chiquito

Navy



1. Alpena
2. AuSable
3. Blizzard
4. Bounty
5. Liberty
6. Merlin

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Specialty & heirloom



1. Jacob's Cattle



2. Orca



3. Desert Song



4. GTS 1701 Yellow Eye



5. Tiger's Eye



6. UC Southwest Gold



7. Pencil Pod Soldier

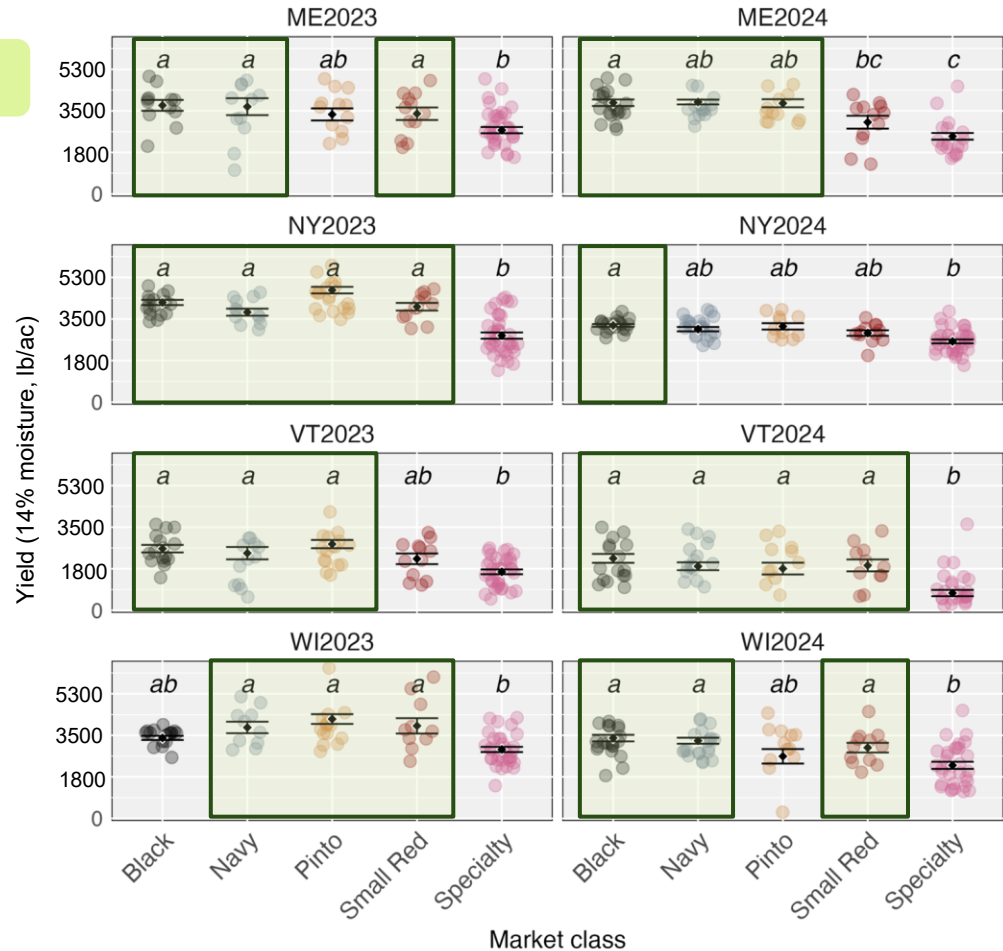
8. Gypsy Rose

9. Keneary Yellow Eye

10. Sow True Marrow

Yield by dry bean market class

- Yield differed between dry bean market classes
- On average, yield from modern market classes outperformed specialty varieties
- Black and navy beans consistently were highest yielding market classes



Yield by dry bean variety

- Best varieties within each market class often varied by location
- Black beans had more uniformity in variety performance than other market classes.



Black Tails



Lariat



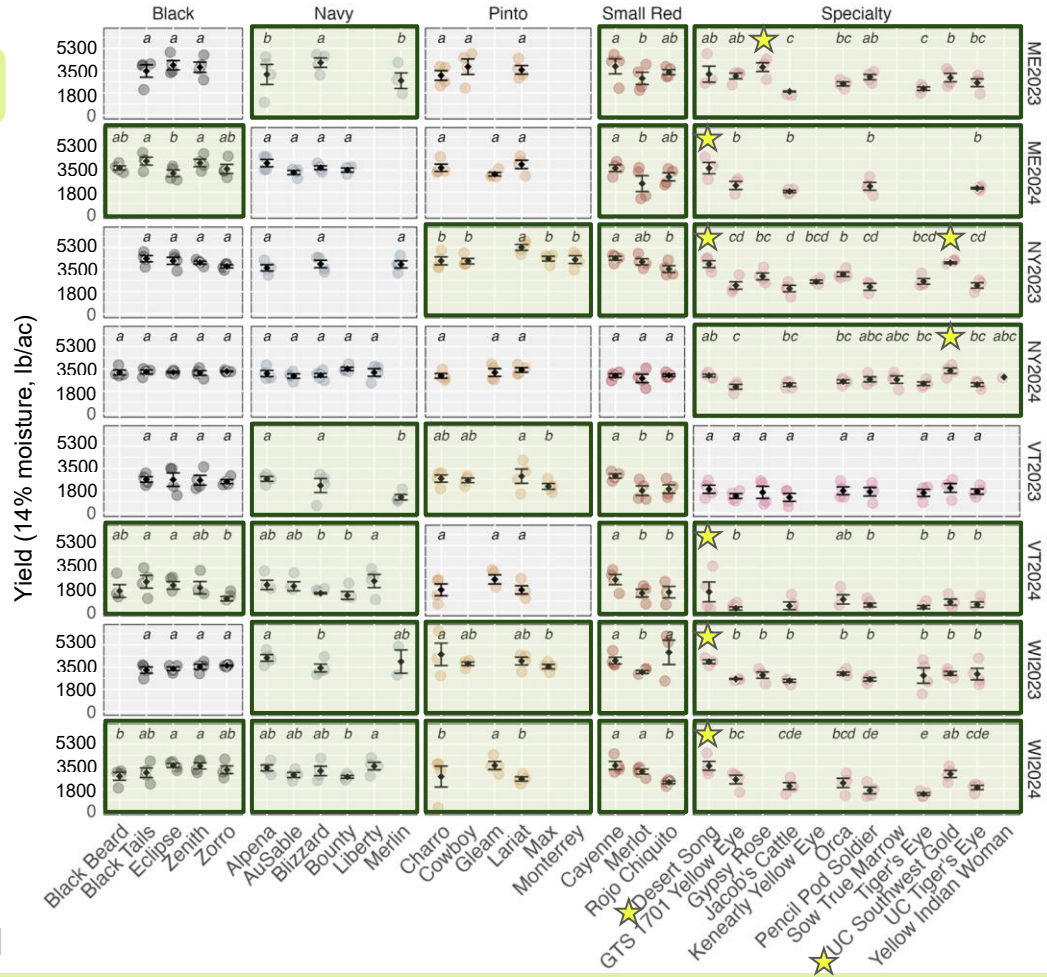
Cayenne



Desert Song



UC Southwest Gold





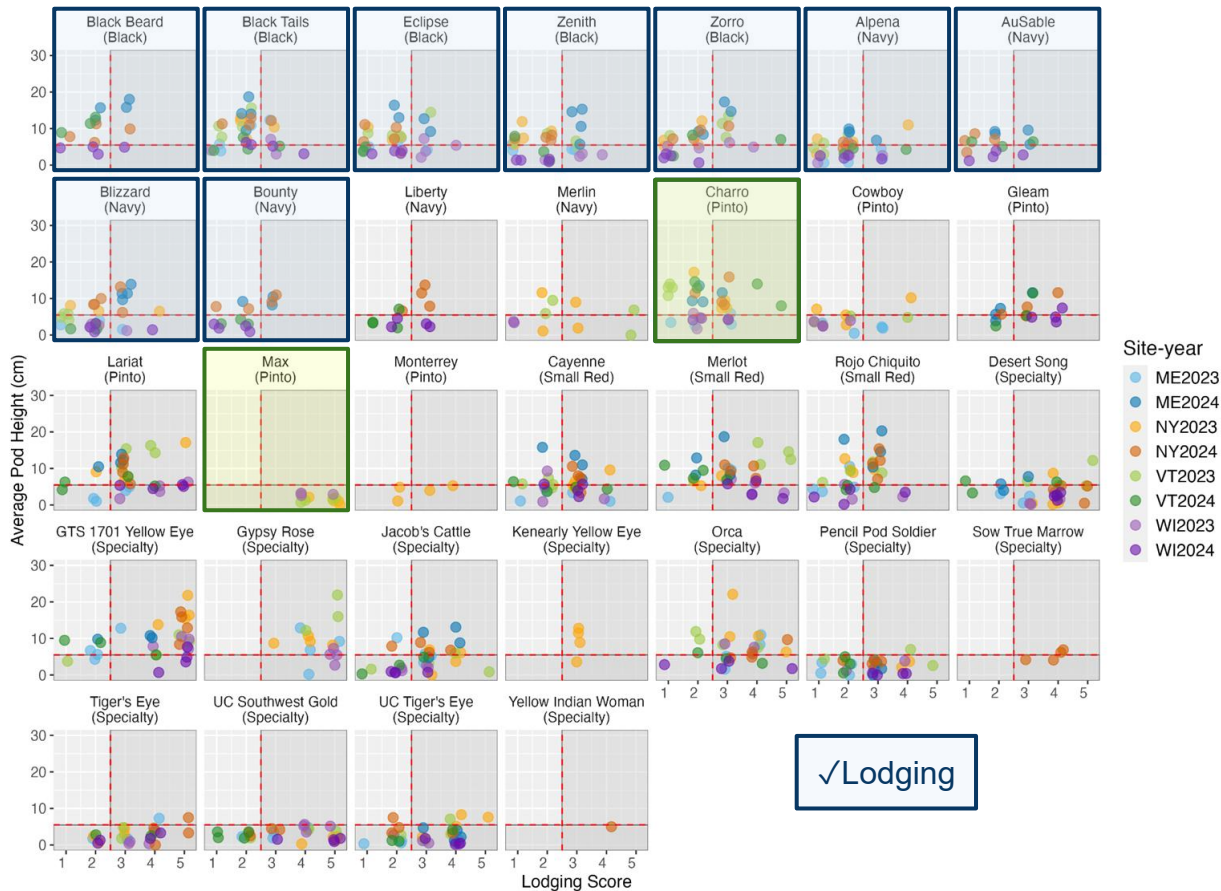
(Kelly, 2010)

Regional variety evaluation of organic dry beans

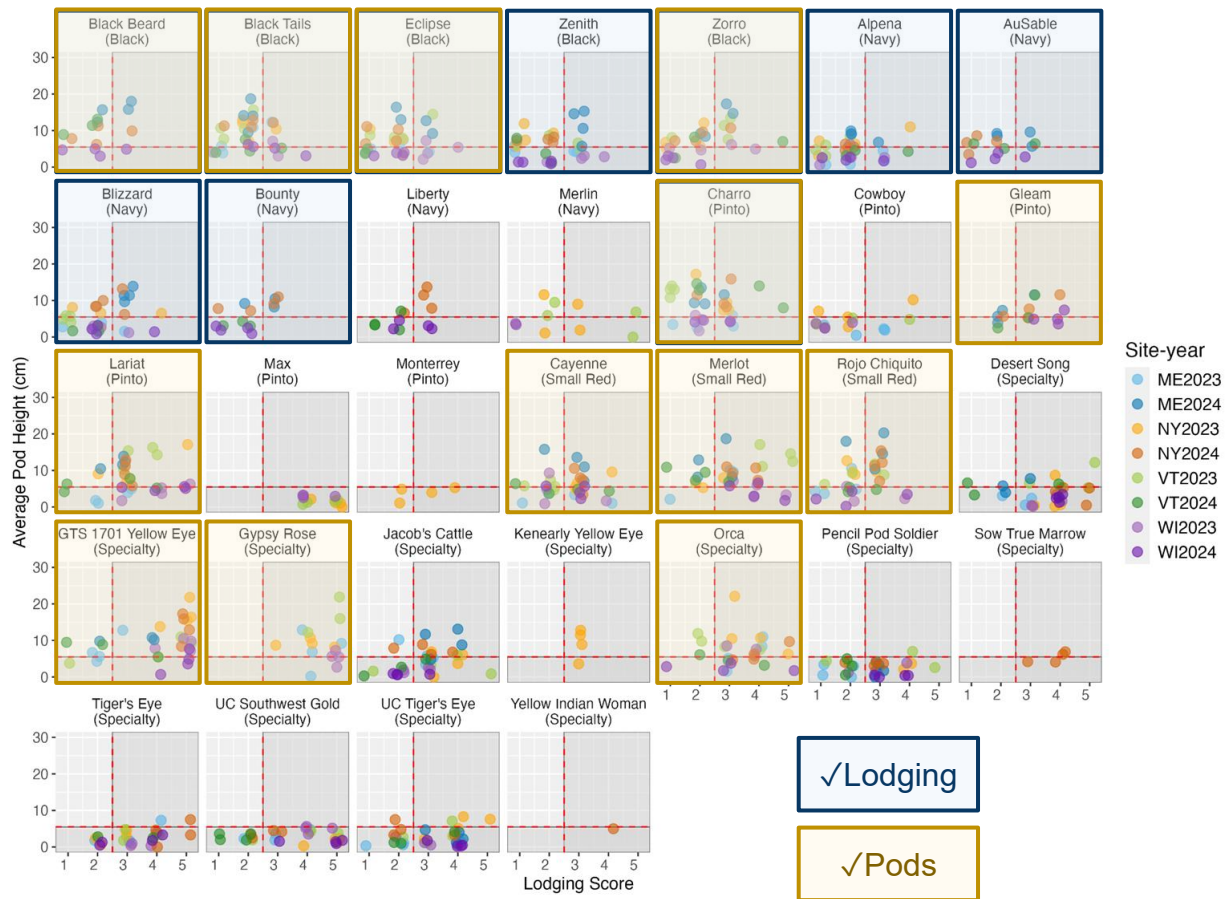
Lodging

Rating Description

1	Almost all plants erect
2	Either all plants leaning slightly or a few plants prostrate
3	Either all plants leaning moderately (45° angle) or 25–50% of plants prostrate
4	Either all plants leaning considerably, or 50–80% of plants prostrate
5	All plants prostrate

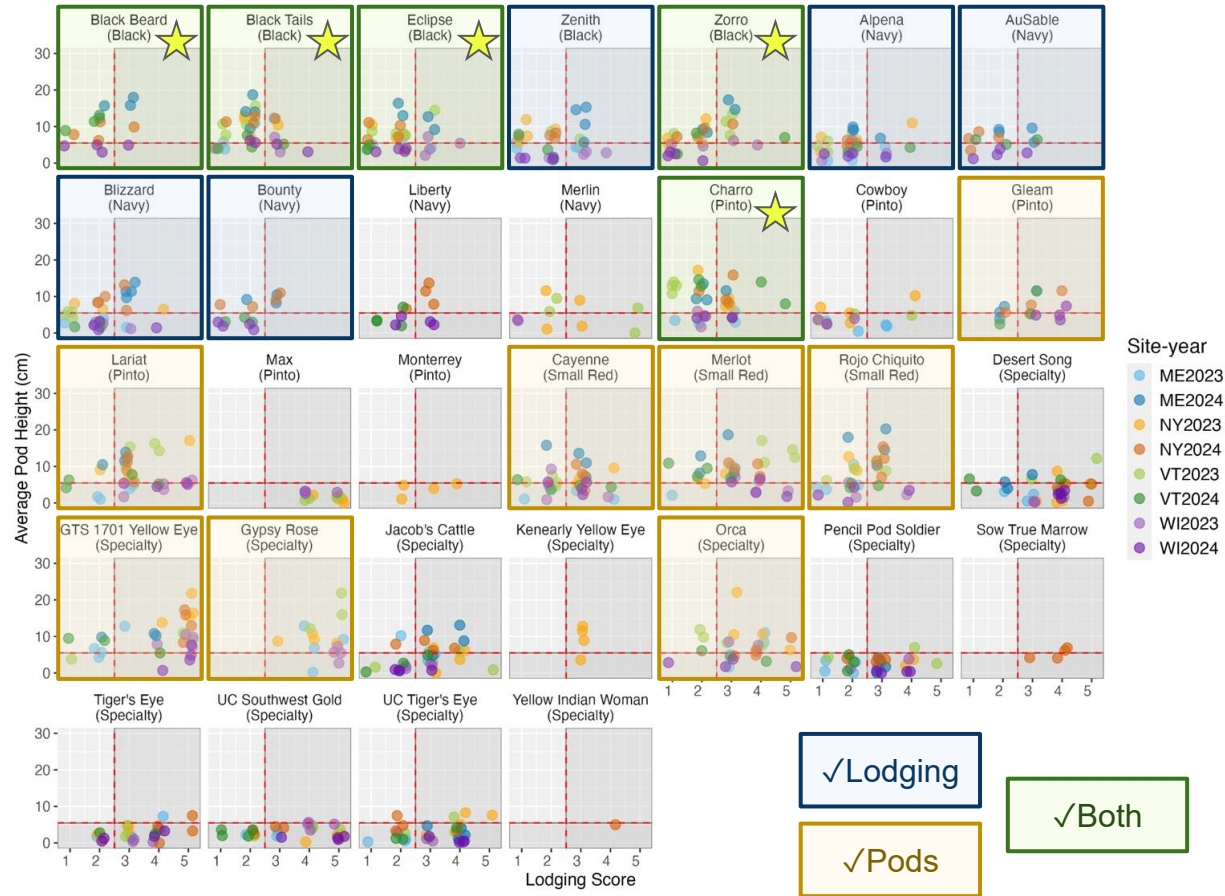


Pod height



Pod height × lodging

- Variability in plant architecture across varieties
- Most varieties do not have the desired combinations of tall pod height and low lodging
- Several **black bean varieties** exhibit desired trait combinations for **yield, lodging, and pod height**



FLAVOR, APPEARANCE, & MARKETABILITY SURVEY

- Beans from 2023 variety trial were sampled in NY, VT, & WI in July–Sept 2024; n = 127
- Beans cooked with salt & water
- Participants given 4/7 samples
- Culinary attributes ranked on Likert scale
- Willingness to pay ranked by prices bins in three markets



Jacob's Cattle



Tiger's Eye,
UC Tiger's Eye



Orca



UC Southwest
Gold



Eclipse (black)



Lariat (pinto)

FLAVOR, APPEARANCE, & MARKETABILITY SURVEY



Jacob's Cattle



Tiger's Eye,
UC Tiger's Eye



Orca



UC Southwest
Gold

Flavor, texture, seed coat

Strongly like

Moderately like

Neither like nor dislike

Moderately dislike

Strongly dislike



Eclipse (black)



Lariat (pinto)

FLAVOR, APPEARANCE, & MARKETABILITY SURVEY

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Price bins (per lb)

\$0–3.00
\$3.01–7.00
\$7.01–11.00
> \$11.00



Jacob's Cattle



Tiger's Eye,
UC Tiger's Eye



Orca



UC Southwest
Gold



Eclipse (black)



Lariat (pinto)

FLAVOR, APPEARANCE, & MARKETABILITY SURVEY

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Jacob's Cattle



Tiger's Eye,
UC Tiger's Eye



Orca



UC Southwest
Gold



Eclipse (black)



Lariat (pinto)

HYPOTHESIS

Respondents will have **preferences for specialty & heirloom varieties** over modern varieties.

Respondents will be **willing to pay more for specialty varieties**, for **organically grown beans**, and in **direct markets**.

Culinary preferences

Flavor:

- UC Tiger's Eye preferred over Orca (S) and Eclipse (B)

Seed Coat:

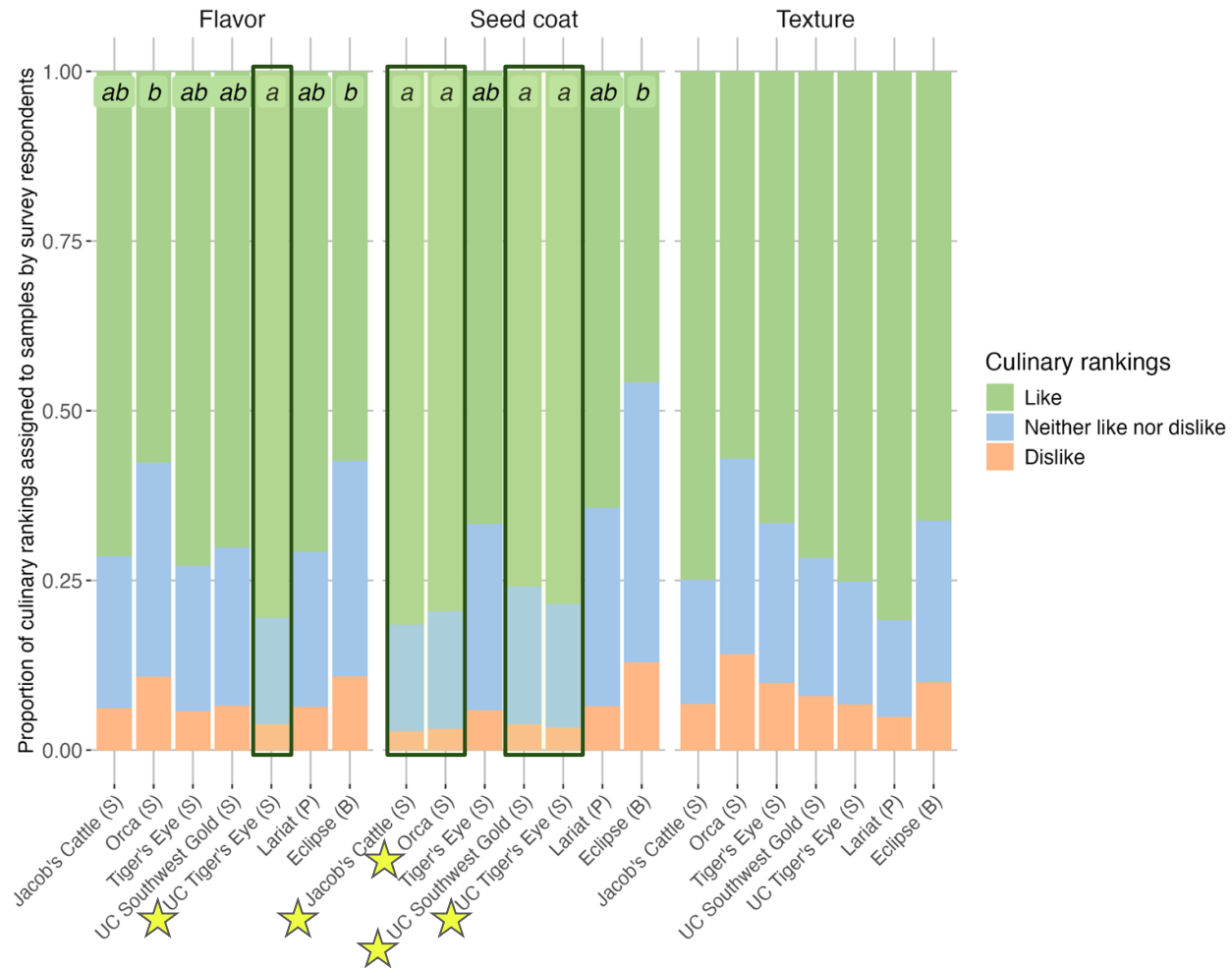
- All rated similarly except Eclipse (B)
- Several specialty varieties did sort towards the top

Texture:

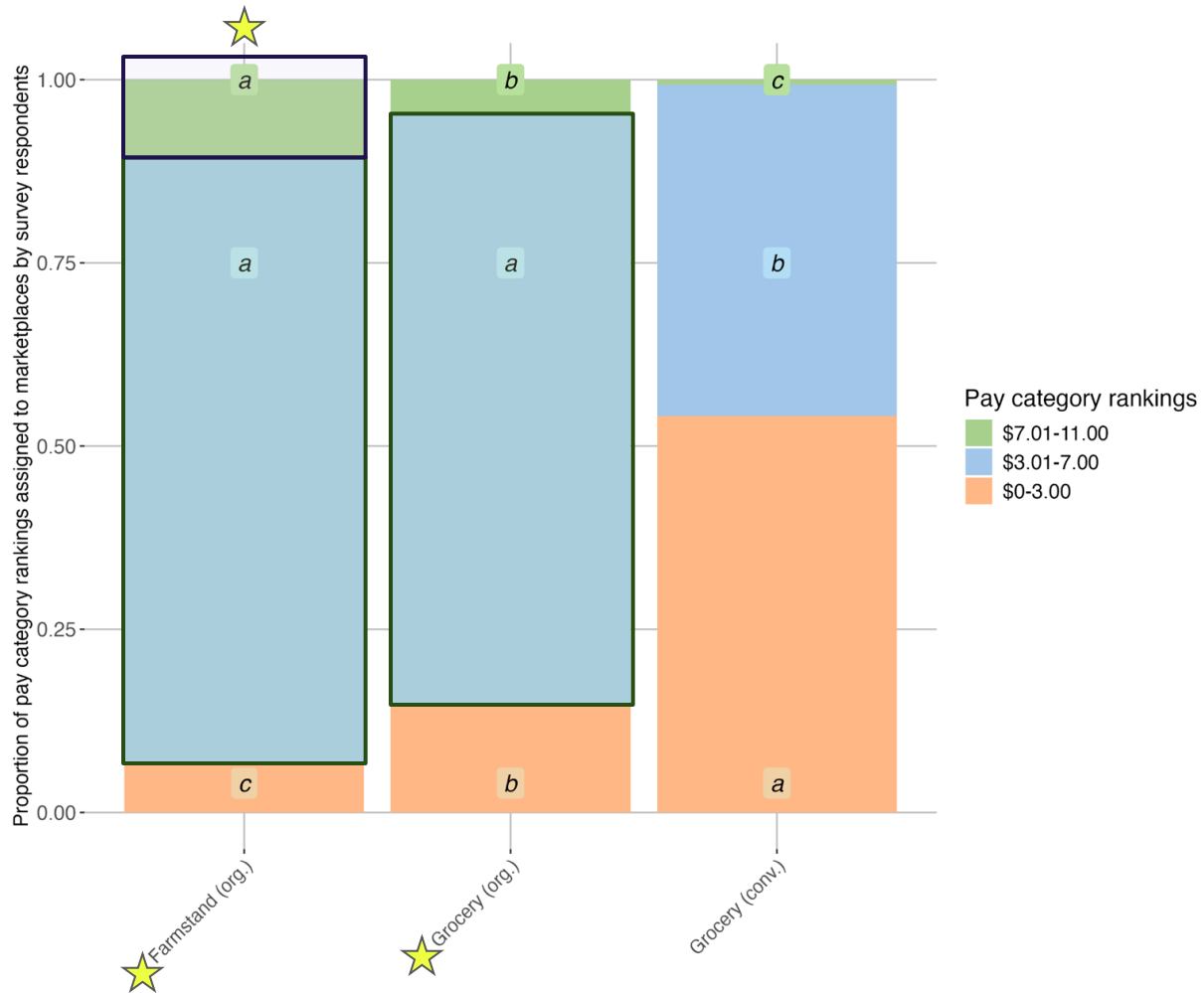
- No differences

Some overall observations

- Jacob's Cattle & UC Tiger's Eye sorted to top in all 3 categories
- Lower preference towards Eclipse (B)

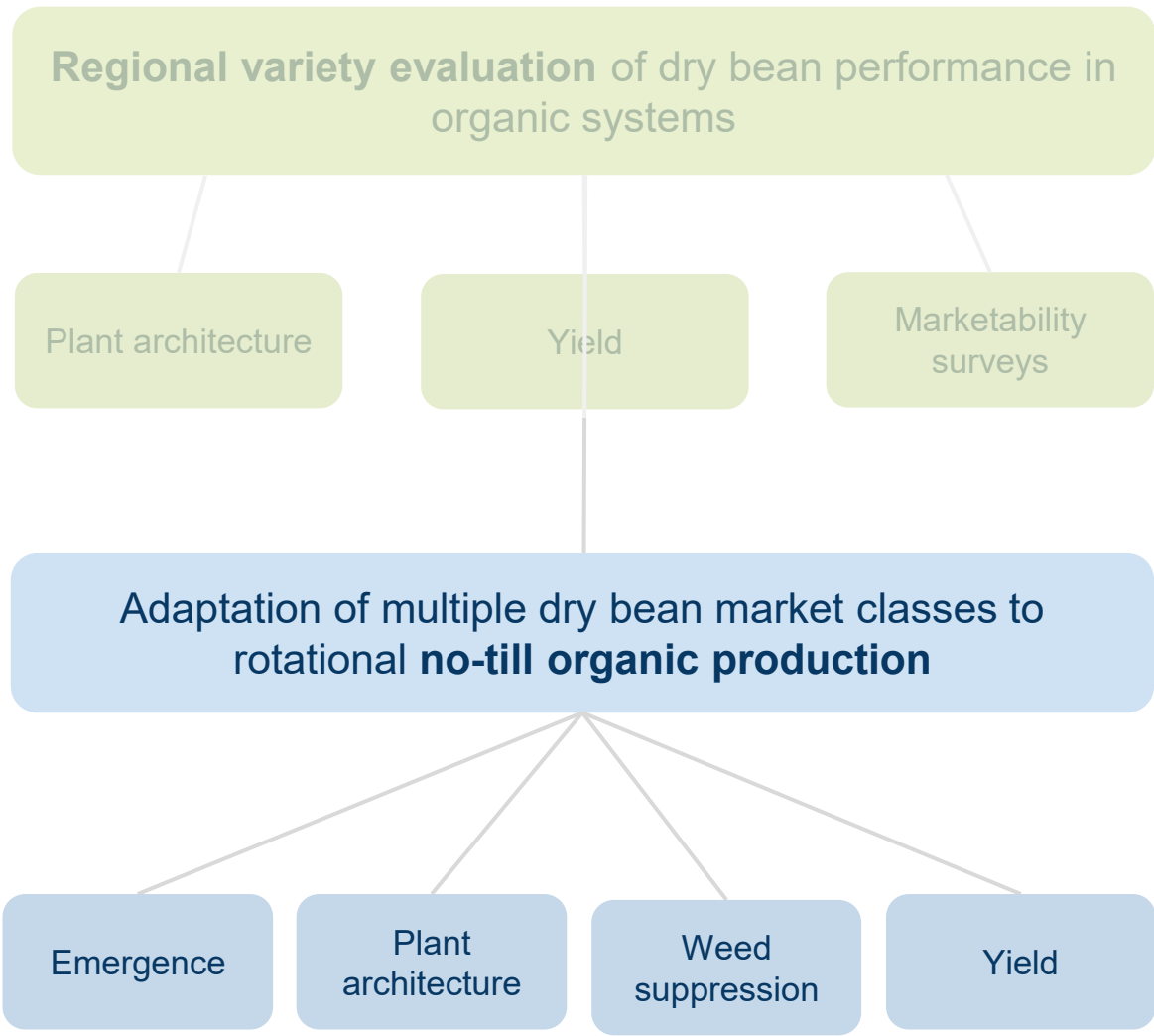


Suitability for high-value markets





Expanding **organic**
dry bean production
in the *northeast &*
upper midwest regions



MARKET CLASS × TILLAGE TRIAL

- Selected 1 variety from each market class to compare in tilled and rolled-crimped systems
- Performed in NY, WI, ME, and VT in 2023-2024
- Represents 6 individual experimental locations
- Measured emergence, weed and crop biomass, lodging, pod height, and yield



Black



Pinto



Small red

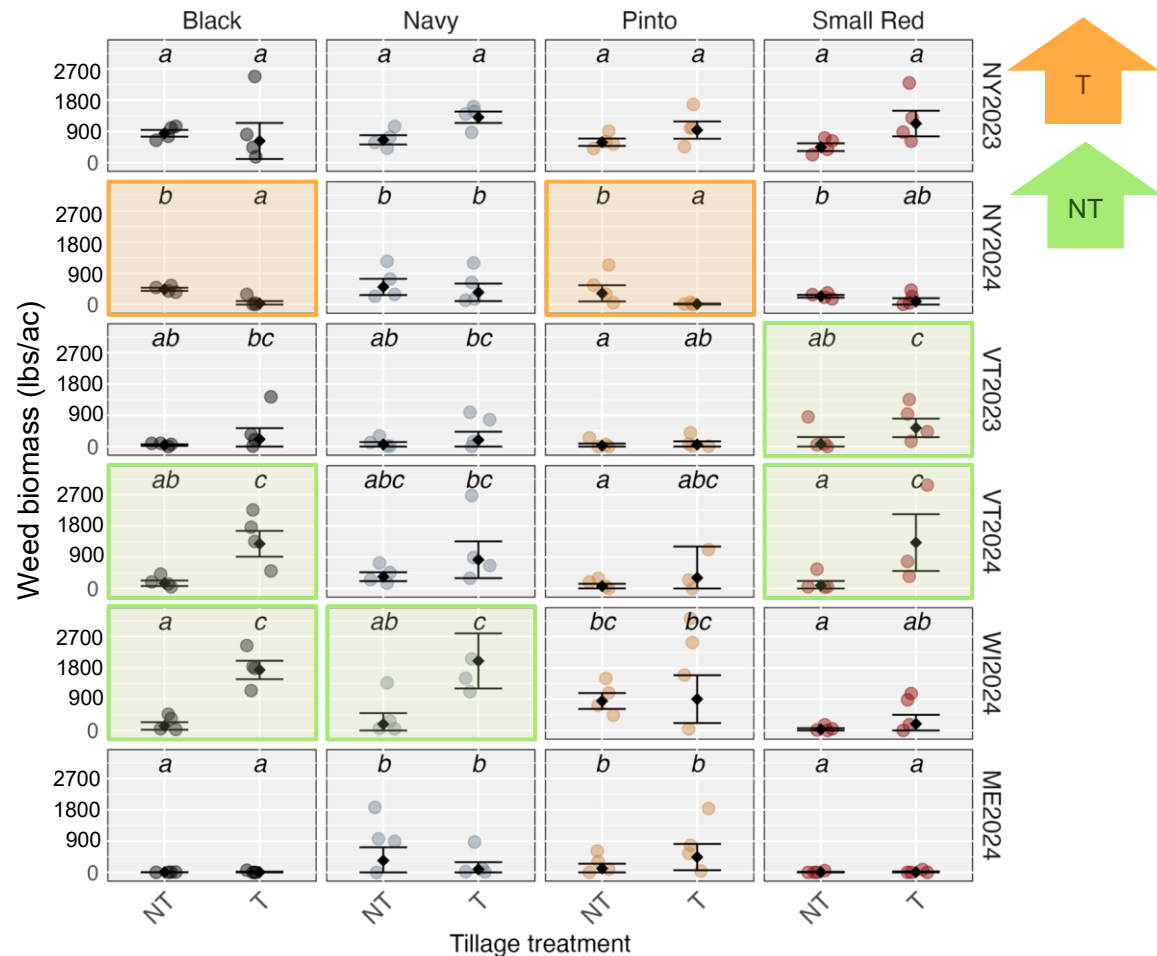


Navy

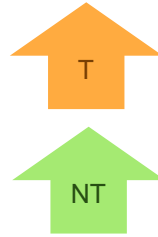


Weeds biomass

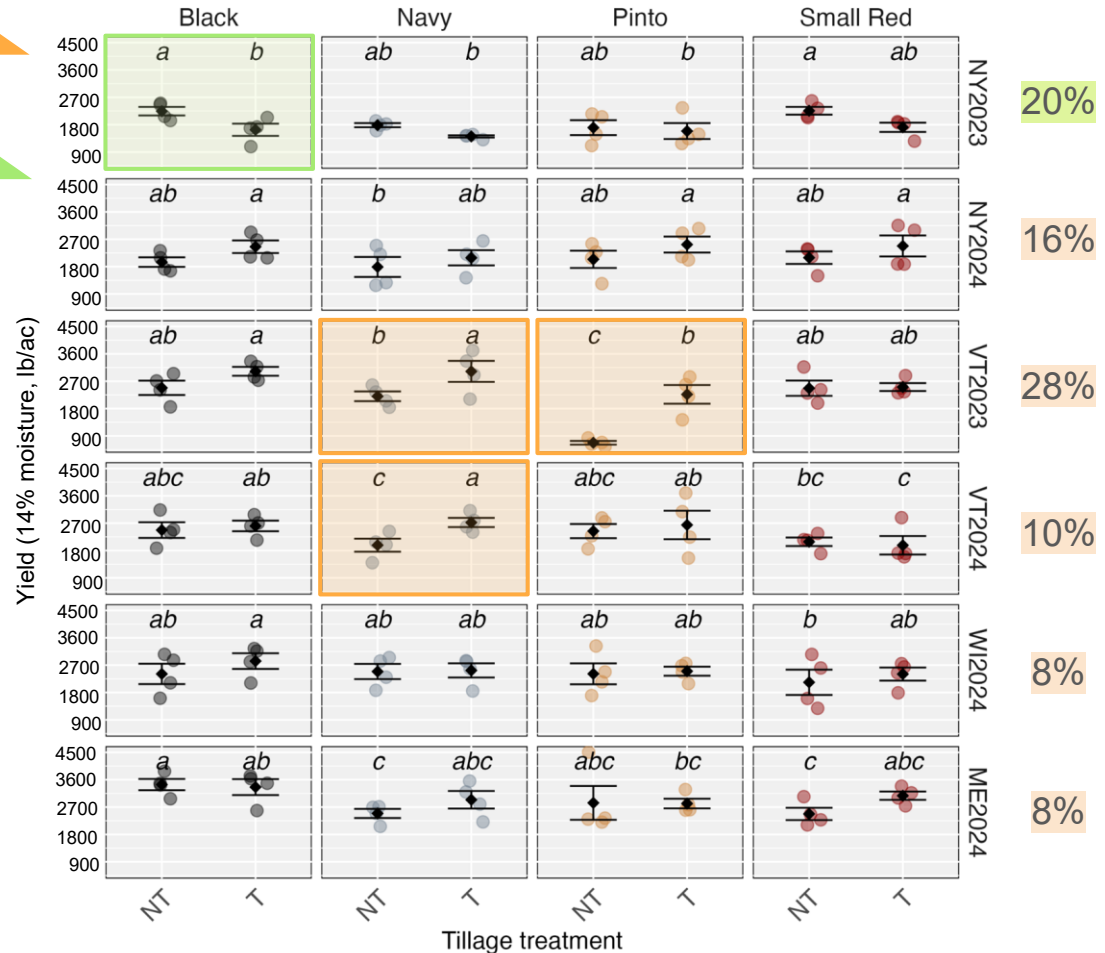
Site-year	Cereal rye $kg\ ha^{-1}$
NY 2023	10,222
NY 2024	10,911
VT 2023	11,488
VT 2024	10,583
WI 2024	13,685
ME 2024	1,699



Yield



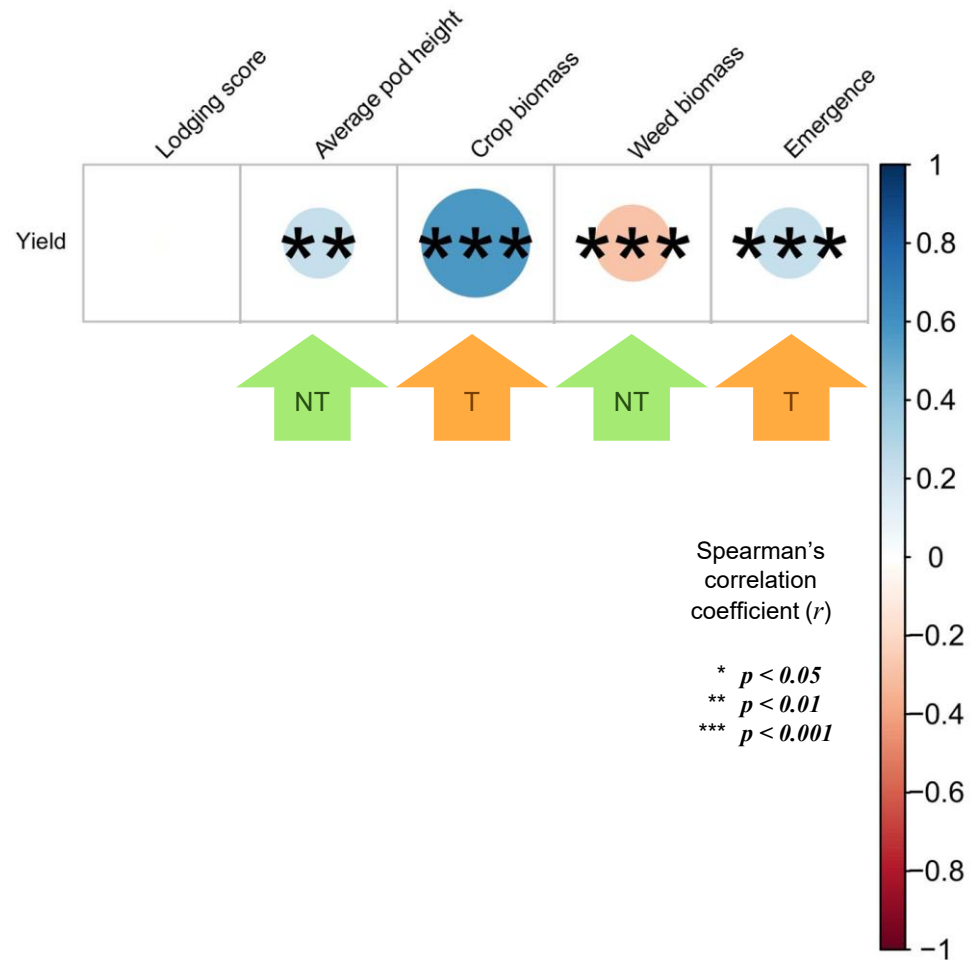
- In only 3 of 24 combinations of comparisons between tilled and no-till did we observe a yield difference
- No-till does have the potential to outyield tillage based systems under certain circumstances
- On average, tilled plots had 9% higher yield



(Knapp & Van Der Heijden, 2018; Pittelkow et al., 2015)

Traits correlated with yield

- Emergence
- Crop biomass
- Weediness
- Pod height



To wrap it up!

- Modern market classes tend to yield higher than specialty – but specialty varieties can carry advantages in direct marketing situation
- Some **specialty varieties yielded competitively** with modern varieties – Desert Song & UC Southwest Gold
- Black beans (Black tails) had best combination of low lodging, tall pod heights, and highest yields
- In no-till systems, dry beans tended to suppress weeds better but yielded on average 9% less.



Adapting seeding rates of dry beans to organic no-till black bean production systems

Spoiler!!

Higher seeding rates improve weed suppression and profitability



Cornell University



THE UNIVERSITY
of
WISCONSIN
MADISON



The University of Vermont



1865 THE UNIVERSITY OF
MAINE

ECOBEAN

Why organic no-till? Benefits of rolled-rye organic systems

Tillage-based management



- Protects against soil erosion
- Improves soil health, water infiltration, and moisture retention
- Suppresses weeds
- Minimizes labor and fuel usage

Cover crop-based, rotational no-till



Cultural weed management

Seeding Timing

Row Spacing

Seeding Rate

Previous work in other crops

BUT

Novel with **dry beans**

Lower yield compared to tilled
with **same** seeding rates used...




(A) Low seeding rate
80,000 seed/ac


(B) High seeding rate
315,000 seed/ac


Objective and hypotheses

Objective: To optimize production of organic black bean no-till planted into rolled-crimped cereal rye

Hypotheses: As black bean seeding rate increases...

Black bean density 

White mold 

Black bean yield 

Weed biomass 

Lodging 

Profits 



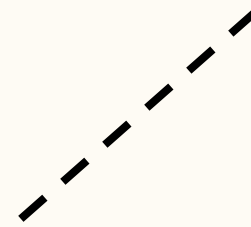
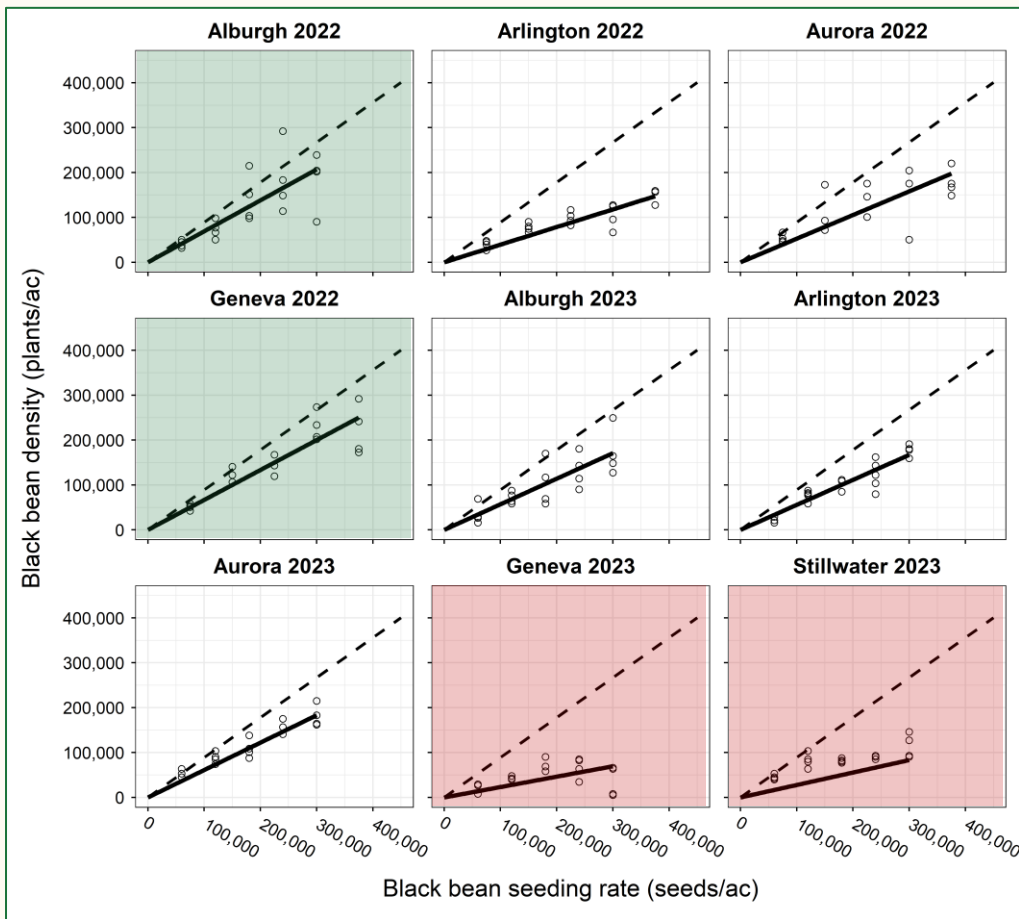
Above: Organic no-till black bean system (NY)

Experiment Design

Treatment	Black bean seeding rate (seeds/ac)
A	60,000 (with 0 sub-plot)
B	120,000 (Conventional practice)
C	180,000
D	240,000
E	300,000

*Three site-years included seeding rates up to 375,000 seeds/ac

Effect of black bean seeding rate on black bean density



= 89% expected germination

High establishment

- Alburgh 2022
- Geneva 2022

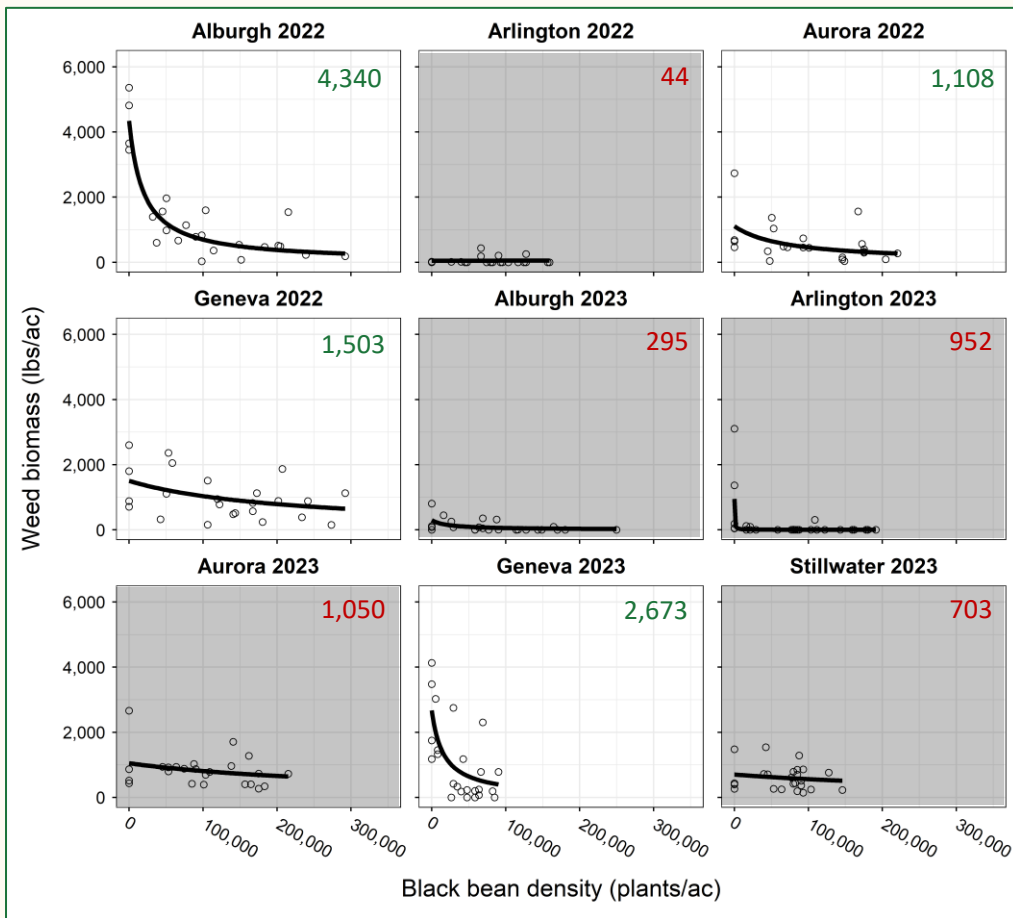
Low establishment

- Geneva 2023
- Stillwater 2023

Potential factors for establishment:

- Suboptimal seed placement
- Low soil temperatures
- Variable soil moisture

Effect of black bean density on weed biomass

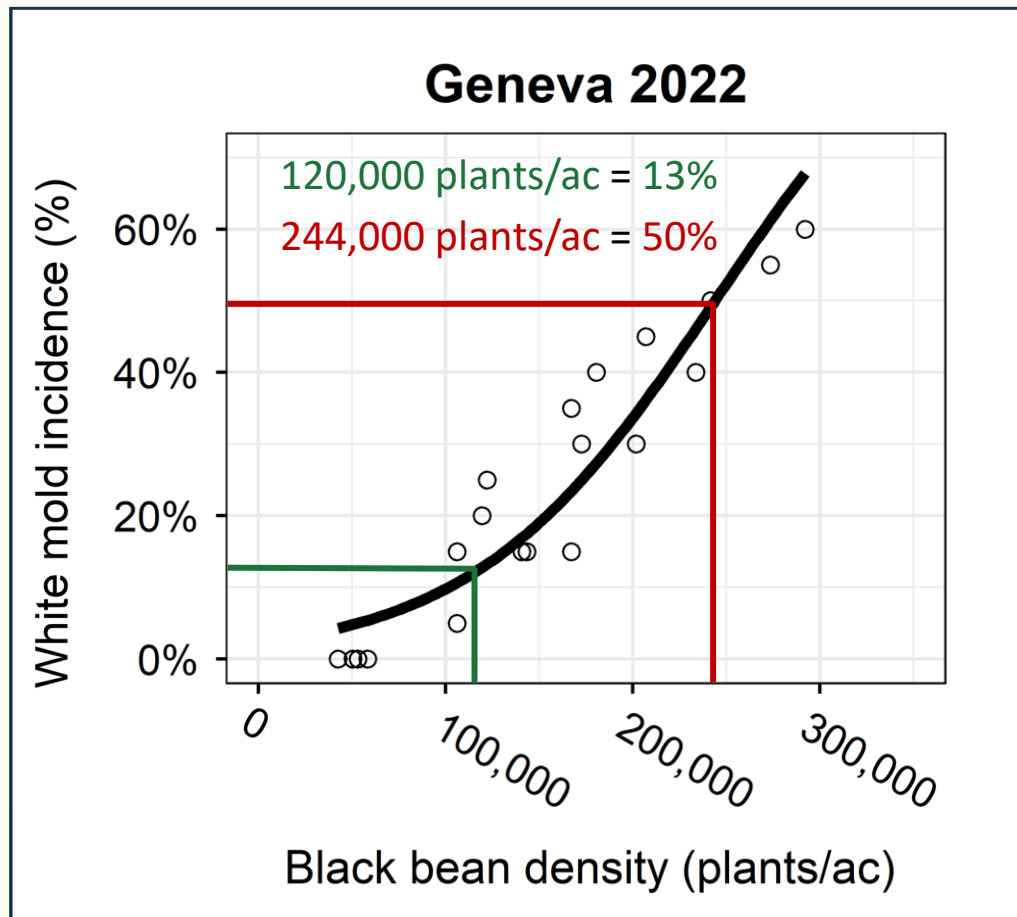


Weed biomass reduced at
4 out of 9 site-years

Increasing black density was
effective when baseline weed
abundance **>1,100 lbs/ac**

Baseline weed abundance = Weed biomass at 0 seeds/ac

Effect of black bean density on white mold incidence/lodging



Increase in white mold incidence in Geneva 2022 and 2023

Field history of white mold

S. sclerotiorum inoculation in 2019

Black bean lodging assessment

1 to 5 rating scale at the plot level

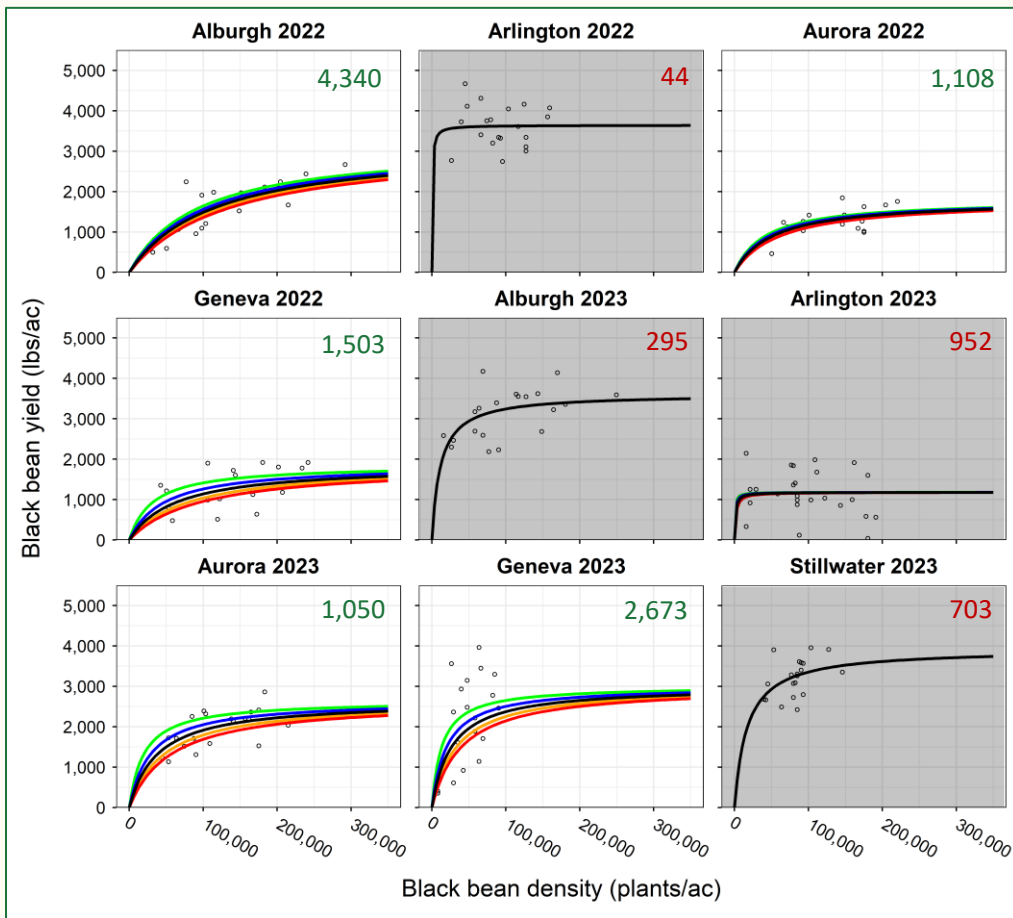


1 = no lodging
:
:
5 = all plants down

Increased lodging in **3 out of 9 site-years**

- Alburgh 2023
- Aurora 2023
- Geneva 2023

Effect of black bean density on black bean yield



Yield improvements observed in **5 of 9** site-years

Baseline weed abundance **>1,000 lbs/ac**

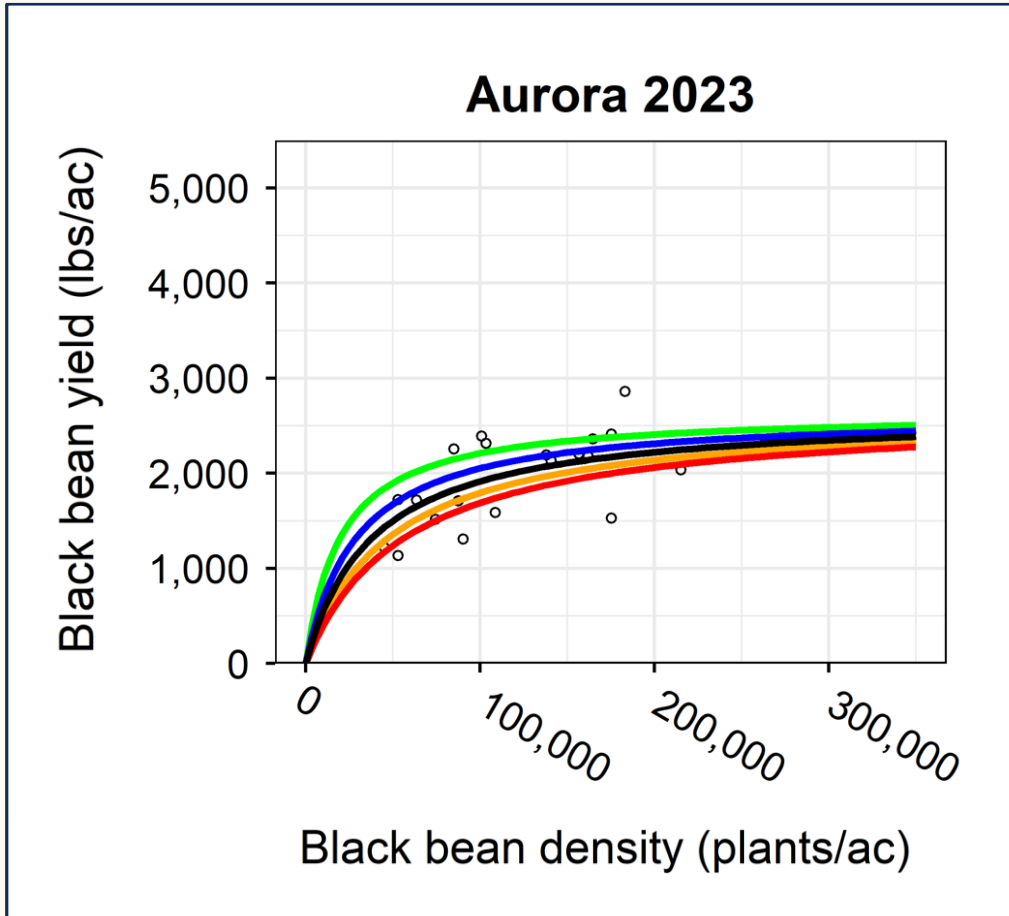
Colored lines	% of site-year average weed biomass across plots
Green	50%
Blue	75%
Black	100% (average)
Orange	125%
Red	150%

Rapid yield plateau under **low** weed abundance

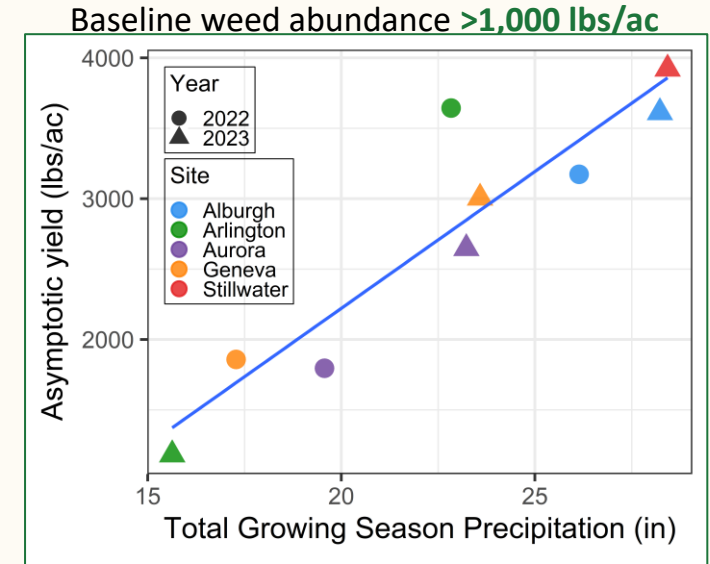
VS

Gradual yield increase under **moderate to high** weed abundance

Effect of black bean density on black bean yield

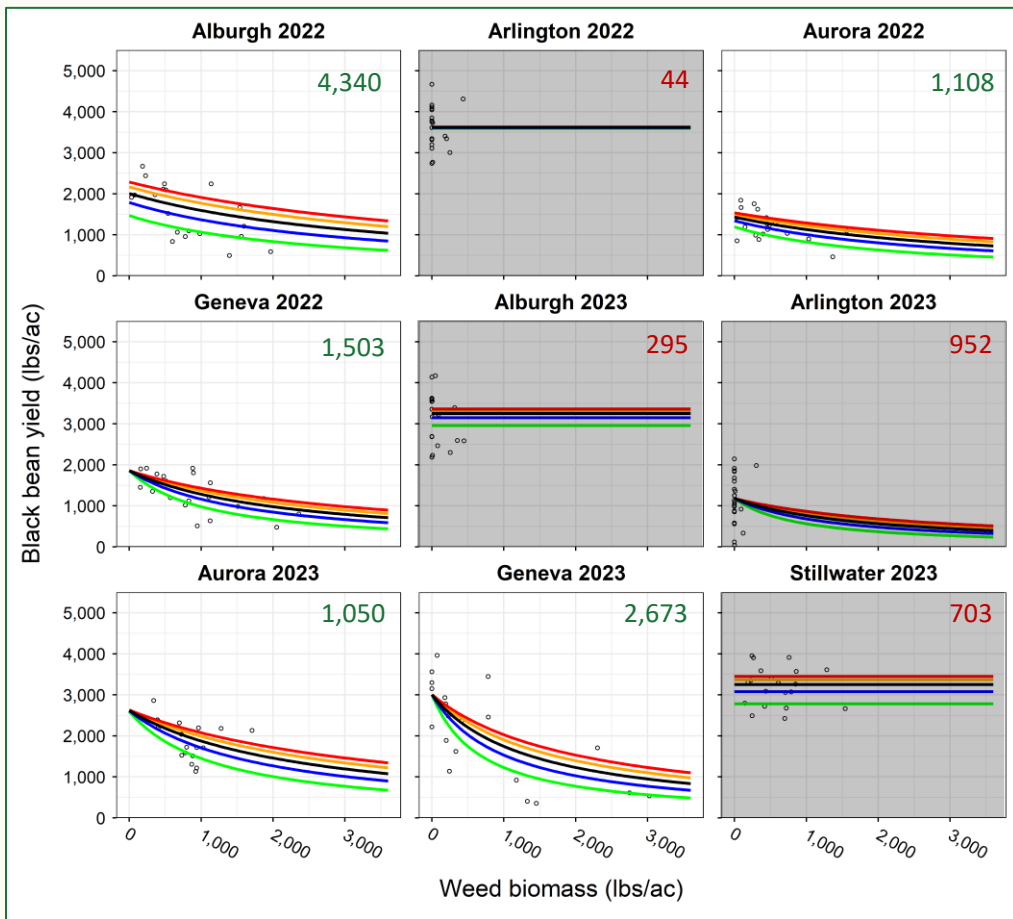


Yield improvements observed in 5 of 9 site-years



Yield plateau at high black bean densities **increased** with growing season precipitation

Effect of weed biomass on black bean yield



Colored lines	% of site-year average black bean density across plots
Green	50%
Blue	75%
Black	100% (average)
Orange	125%
Red	150%

Ex: Aurora 2023

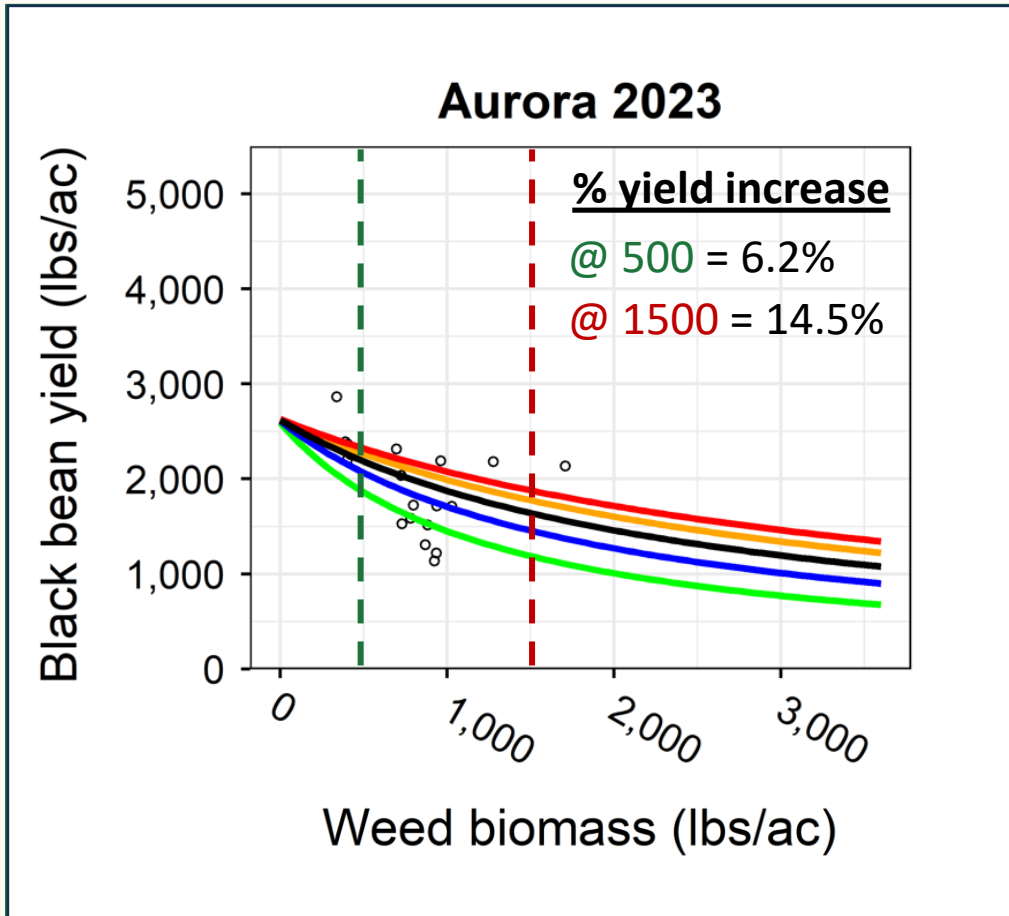
Black = 178,000 plants/ac

Red = 267,000 plants/ac

Higher black bean density
reduced yield loss from weeds

- Effect **strongest** at high weed biomass

Effect of weed biomass on black bean yield



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Profitability: Partial Budget Analysis

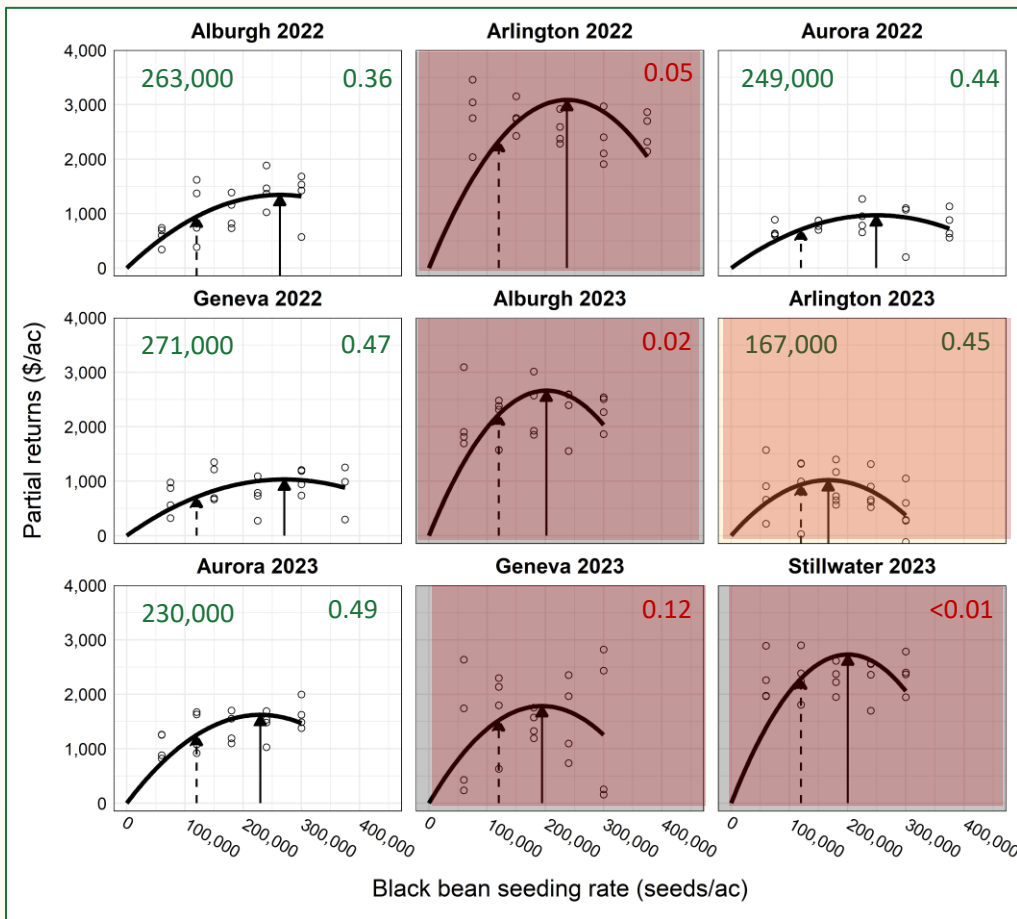
Partial Returns were calculated as:

$$P_r = (Y_B \times M_p) - (B_r \times C_s)$$

where...

- P_r = Partial return (\$/ac)
- Y_B = Black bean yield (lbs/ac)
- M_p = Estimated cannery price of \$0.75/lb for organic black beans in New York
- B_r = Black bean seeding rate (seeds/ac)
- C_s = Black bean seed cost of \$0.00048/seed

Effect of black bean seeding rate on partial returns



Conventional
seeding rate
(120,000 seeds/ac)



Optimal
seeding rate

Conditional R² > 0.30

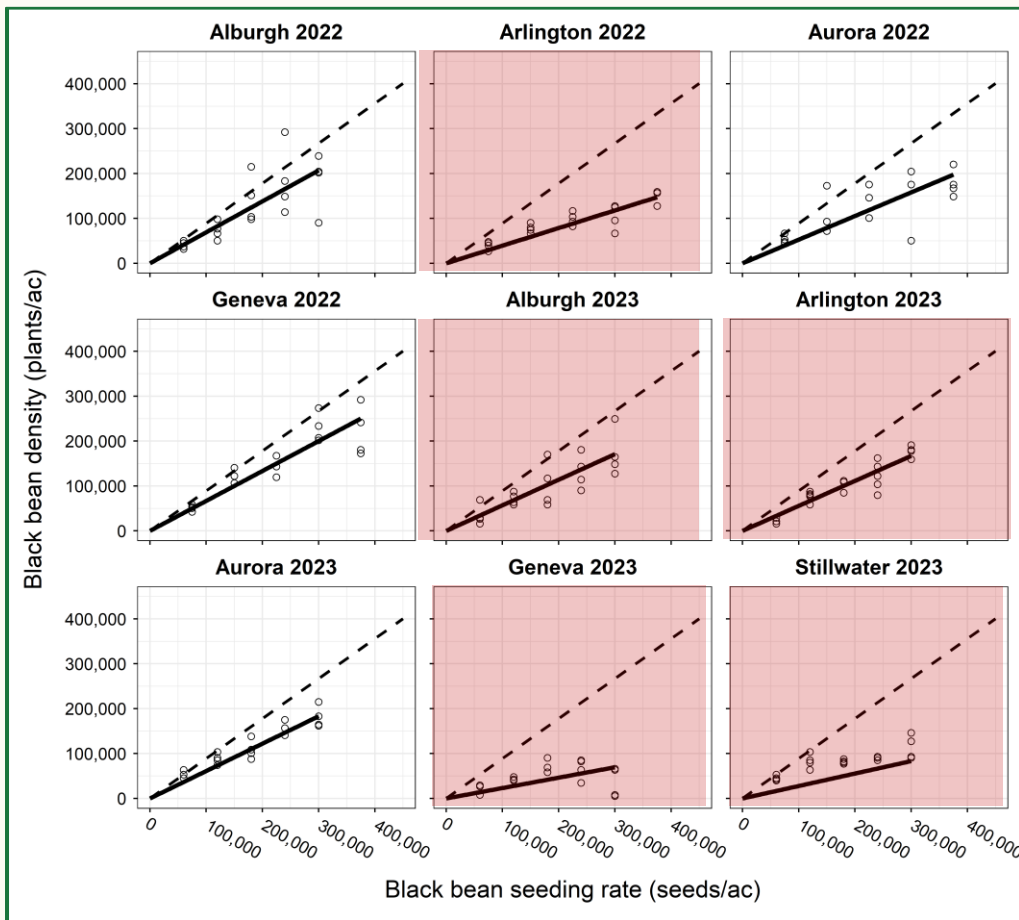
Optimal seeding rate: $\geq 230,000$ seeds/ac

Under conditions of...

- Adequate density gradient achieved
- Baseline weed biomass > 1,000 lbs/ac

Economic gains of \$261 to \$397/ac
relative to conventional rate

Effect of black bean seeding rate on partial returns



Conventional
seeding rate
(120,000 seeds/ac)



Optimal
seeding rate

Conditional $R^2 > 0.30$

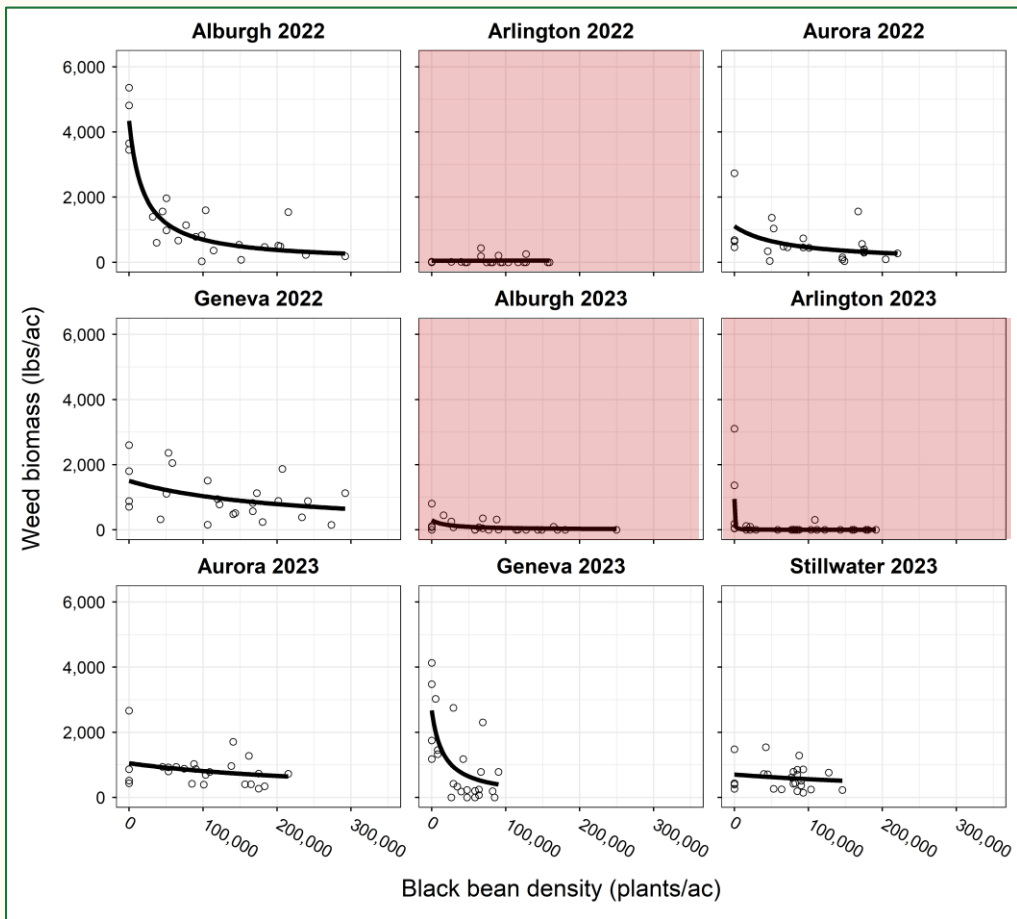
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- Adequate density gradient achieved
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Economic gains of **\$261 to \$397/ac**
relative to conventional rate



Main conclusions

For organic no-till black bean production:

- **Higher densities** reduced weed biomass under **moderate-high weed abundance**
- **White mold increased** with higher densities in fields with a **history of the disease**
- **Lodging at higher densities** was observed at **3 out of 9 sites**
- **Increasing black bean density** limited **yield losses from weed competition**
- **≥230,000 seeds/ac** in **weedy conditions** maximized **economic returns**



Takeaway message

For organic no-till black bean production

Increasing seeding rates beyond conventional practice can **improve yield and profitability**, but benefits depend on **weed abundance** and require **site-specific adjustments** to manage **white mold and lodging risks**

When to mow? Improving weed control in organic no-till dry bean



Excellent suppression in a rolled-rye no-till system



When Mulch Fails: Weed Breakthrough in Rolled Rye



R-Tech inter-row mower: A tool for controlling weeds without disturbing the soil



What it is:

- IRM X4 interrow mower (R-Tech Industries, Homewood, MB, Canada)

How it works:

- Five 22-inch rotary mowers that operate between crop rows
- Cuts weeds 2–6 inches above the soil surface
- Minimizes soil disturbance

Operational constraints:

- Used until canopy closure increases risk of crop damage

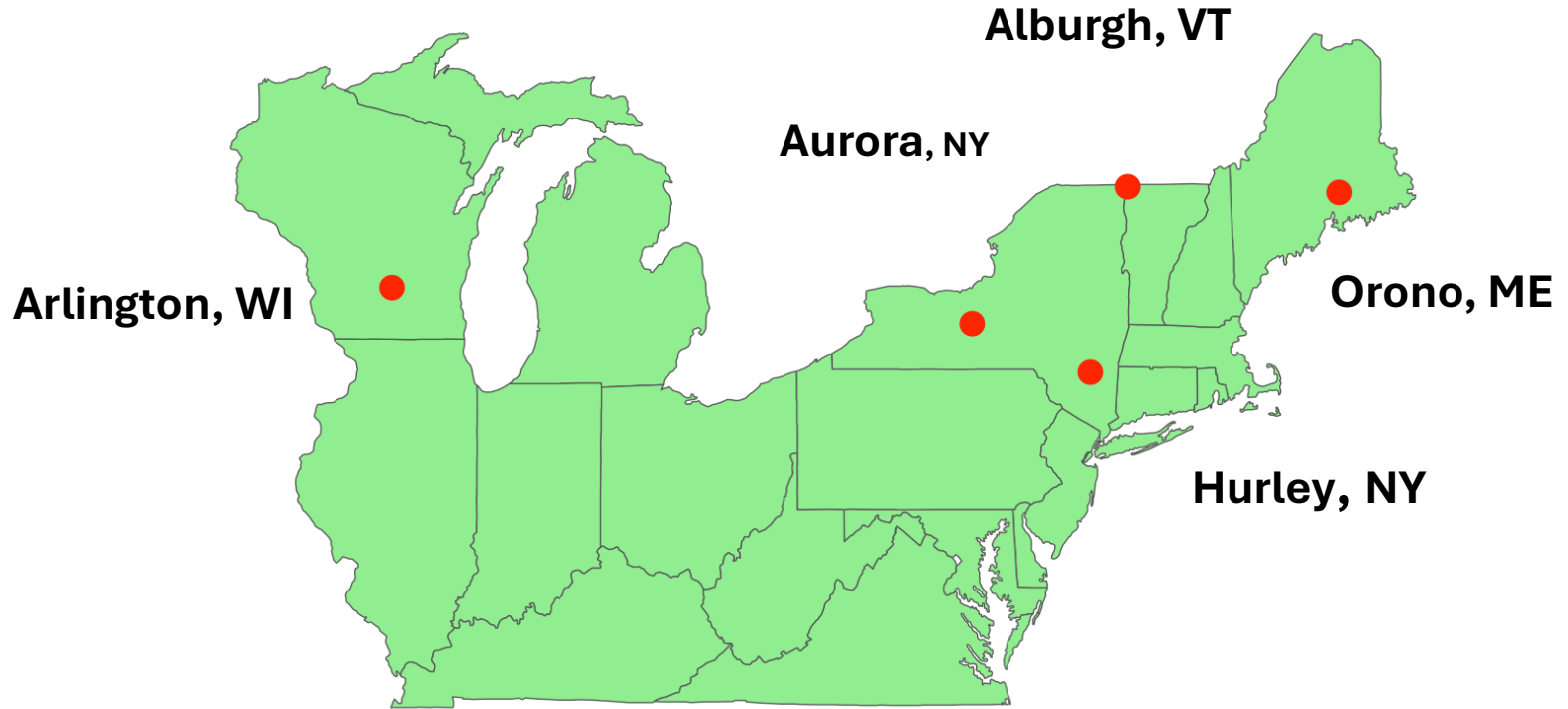
Inter-row mowing in action



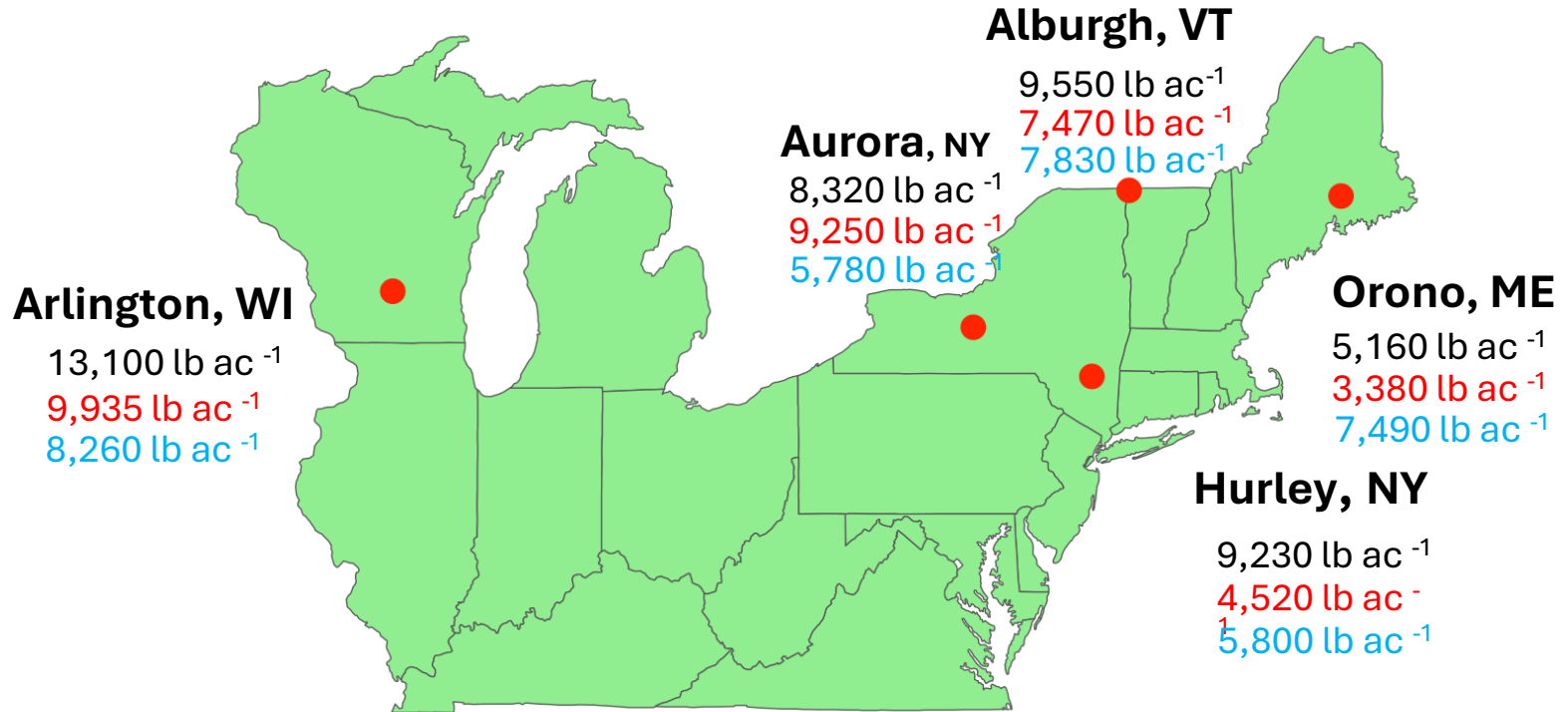
Experimental design: mowing timing in organic no-till dry bean

Experimental Treatments	
Treatment Name	Definition
Early Mowing	A single mowing event between V2-V4 bean growth stages and once > 50% of weeds reach a height of eight inches.
Late Mowing	A single mowing event prior to seed maturation of dominant weed species.
As-Needed Mowing	At least two mowing events, starting between V2-V4 bean growth stages once > 50% of weed reach a height of eight inches, repeated when > 50% of weeds reach a height of eight inches, and with a final mowing prior to seed maturation of dominant weed species.
No Mowing	No interrow mowing.

Study Locations: 15 site-years across four states



Mulch biomass variation across sites (2023–2025)



For adequate weed suppression, roller-crimped cover crop biomass must produce **4,460 to 7,130 lb ac⁻¹** (Ryan et al. 2011)

Simulated weed pressure using surrogate species



- Cover crops used as proxies for weed functional groups
 - Japanese millet → C4 grasses
 - Yellow mustard → broadleaf annuals
 - Sunn hemp → annual legumes
- One 3 × 3 m surrogate weed microplot per plot, established at dry bean planting
- All surrogate weed species planted at 4× their recommended seeding rates to create strong weed pressure

Measuring weed seed rain



Seed rain determines future weed pressure — a key metric for long-term weed management

Trap design:

- 100-mm diameter funnel traps
- Mesh collection bags

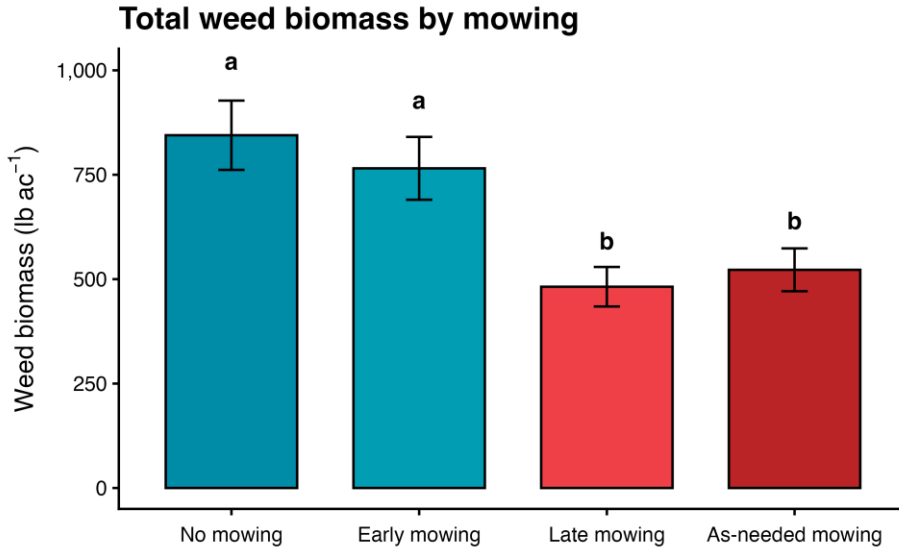
Placement:

- Three traps per plot
- Positioned at soil surface, outside surrogate microplots

Sampling:

- Seed rain collected weekly after final mowing even to bean harvest

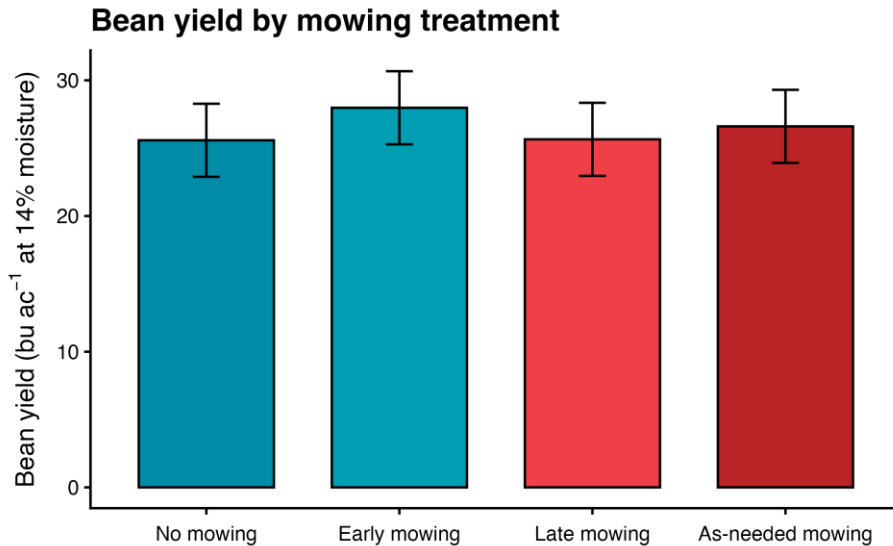
Interrow mowing reduced weed biomass



- Results are **pooled across 15 site-years** at five locations (2023–2025).
- Early mowing did not reduce weed biomass compared with the **no-mowing control**.
- Late and as-needed mowing reduced total weed biomass by **about 40–50%** compared with the **no-mowing control**.

Total weed biomass by mowing treatment. Bars show raw mean weed biomass (kg ha⁻¹) ± SE across ambient and surrogate weed microplots, pooled over 10 site-years. A Tweedie GLMM detected a significant effect of mowing on weed biomass ($p < 0.001$) and no mowing × weeds interaction ($p = 0.86$). Similar letters indicate no significant difference among mowing treatments (Fisher's LSD test, $p > 0.05$).

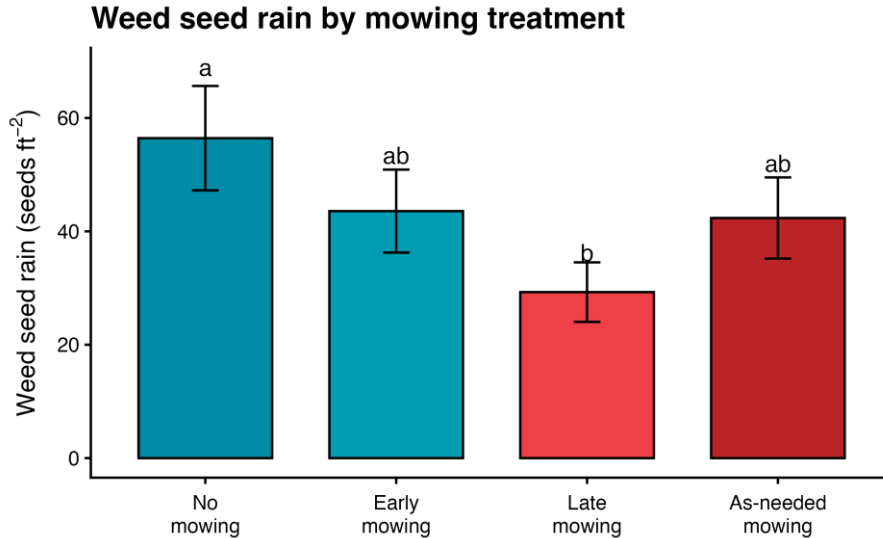
Dry bean yield was similar across weed-management systems



- **Results are pooled across 15 site-years** at five locations (2023–2025).
- **Bean yield was similar across mowing timings**; the mixed model detected no significant effect of mowing on yield ($p = 0.125$).
- **Yield varied with weed pressure and site-year**, not with when we mowed.

Bean yield by mowing treatment. Bars show mean bean yield (bu ac⁻¹, adjusted to 14% moisture) \pm SE across mowing treatments, pooled over 15 site-years and ambient + surrogate weed microplots. A Gaussian linear mixed model with fixed effects for mowing, weediness, and site-year and random effects for site-year, block(site-year), and mowing within block(site-year) detected no significant effect of mowing on yield (Type-III test, $p = 0.125$).

Interrow mowing reduced weed seed rain



- **Results are pooled across 8 site-years** at four locations (2023–2024), and seed rain varied widely among site-years.
- **Late mowing reduced weed seed rain by ~ 45–50% compared with no mowing.**

Weed seed rain by mowing treatment. Bars show Tweedie GLMM-predicted marginal means of seasonal weed seed rain (seeds ft⁻² season⁻¹) ± SE across mowing treatments, pooled over site-years. The model included mowing treatment and site-year as fixed effects and a random intercept for block nested within site-year, and detected a significant effect of mowing on seed rain ($p = 0.026$). Similar letters indicate no significant differences among treatments (Fisher's LSD test, $p > 0.05$).

In Summary

- Rolled-rye mulch alone sometimes fails; interrow mowing provides consistent supplemental weed control.
- Late and as-needed mowing reduce weed biomass by ~40–50%.
- Mowing timing does not reduce dry bean yield.
- Late mowing significantly reduces weed seed rain (~45–50%).
- Interrow mowing is a practical tool to stabilize organic no-till performance across variable site conditions.

Acknowledgments

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- Matthew Ryan's lab, Cornell University
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- Heather Darby's lab, University of Vermont
- Ellen Mallory's lab, University of Maine
- Andrew Casner, Tayler Reinman, Jeff Arnold
Hudson Valley Farm Hub



Dry Bean planting, May 22, 2024

Funding received from:

- Organic Agriculture Research and Extension Initiative (OARI)



College of Agriculture
and Life Sciences



The University of Vermont



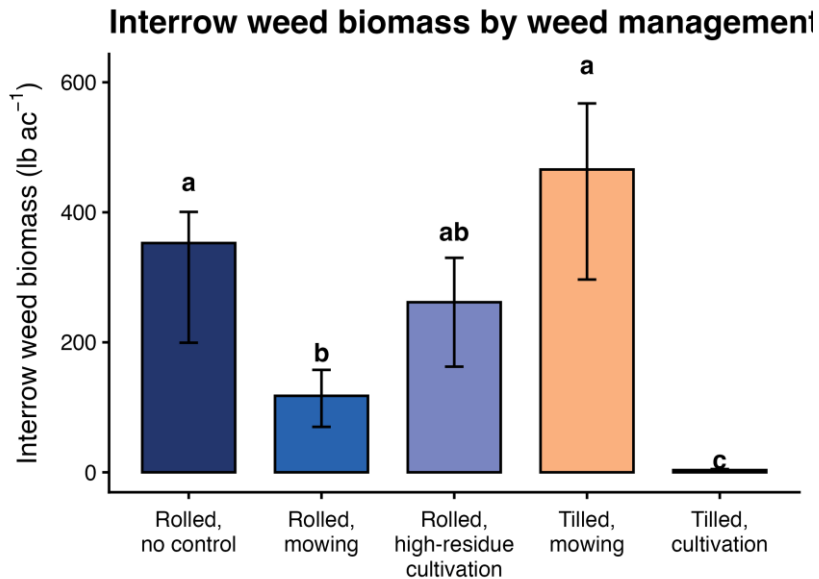
THE UNIVERSITY
of
WISCONSIN
MADISON



THE UNIVERSITY OF
MAINE



Interrow mowing reduced weed biomass (soybean with different tools)



- Weed pressure varied by site-year; 2023 Field V had the highest pressure.
- In 2023, **Tilled, mowing (TIM)** had the highest weed biomass; **Rolled, mowing (RIM)** was among the lowest.
- Rolled systems with mowing had lower interrow weed biomass than rolled rye with no supplemental weed control (RNO).

Interrow weed biomass by weed management (2023). Bars show mean interrow weed biomass (lb ac⁻¹) ± SE across weed management treatments. A linear mixed model with weed management as a fixed effect and block as a random effect detected significant treatment differences ($p < 0.05$). Similar letters indicate no significant difference among treatments (Fisher's LSD test, $p > 0.05$).