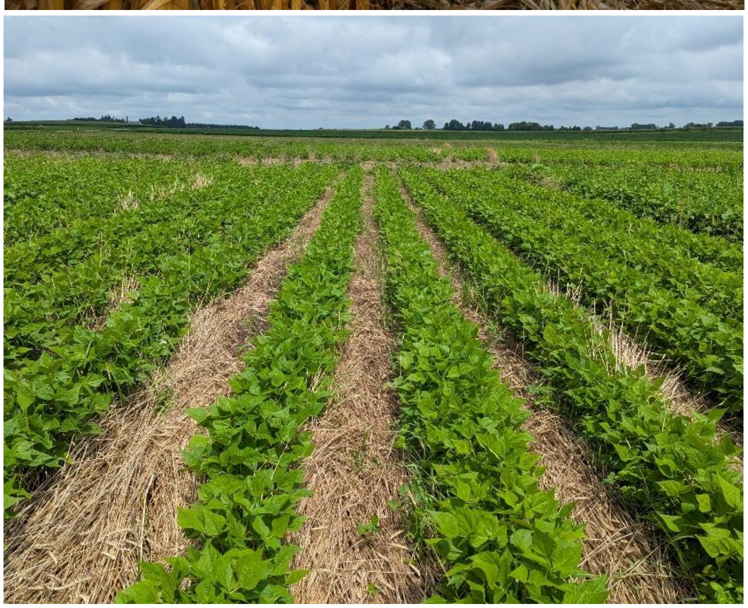
2025 OGRAIN Research Report

University of Wisconsin-Madison Organic and Sustainable Agriculture and Extension Program



Purpose

This is the 2025 research progress report for the UW-Madison Organic and Sustainable Agriculture and Extension Program led by Dr. Erin Silva at the University of Wisconsin-Madison. The report was written with the intention of sharing our latest findings and project updates from our 2025 research trials with the organic community in Wisconsin. The results presented here characterize the preliminary data collected during the 2025 growing season, unless otherwise stated. **Therefore, all conclusions are tentative as additional experimentation in subsequent years may produce different conclusions than results from any one year.**

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Acknowledgements

With it being our 10-year anniversary with OGRAIN we would like to offer many thanks to our collaborators from the Universities of Wisconsin, Vermont, Maine and Cornell for their partnership with us in carrying out the research presented within this report. This work is only possible through the dedicated support and assistance from the staff at the Arlington Agricultural Research Station in Arlington, WI for their technical support and carrying out field management activities. Finally, we would also like to thank the farmers, researchers and industry experts who generously give their time to support the program.

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To connect with the OGRAIN program and to stay up-to-date on our research and other projects please visit our website at www.ograin.cals.wisc.edu. You can also join our listerv where we share regular research updates by emailing ograin+subscribe@g-groups.wisc.edu. Follow us on YouTube, or Instagram. To learn more about our no-till dry bean production please visit our resource guide on organic dry beans .

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Balancing the frequency of fall tillage in organic reduced tillage soybean systems

Main Takeaways

1. Revenues were optimized when winter rye was seeded at 130 lbs/ac and paired with 4 passes of fall field cultivation OR where rye was seeded at 195 lbs/ac and paired with 1 pass of fall field cultivation.

2. Weed biomass was lower when 4 passes of fall field cultivation were used as compared to no fall tillage passes. This mirrored results of germinated weed seeds from each treatment in a greenhouse setting which were not statistically different.

3. Soybean yield was 29.8 bu/ac lower where no fall tillage was done as compared to treatments that utilized fall tillage. However, yield did not differ by the frequency of fall field cultivation passes within treatments that did utilize fall tillage.

The tillage paradox in organic no-till systems

Tillage is the primary method of weed control in many organic systems. In addition to in-season cultivation, false seedbed tillage is a common organic weed management strategy to lower the soil seedbank through concurrent tillage passes to induce and terminate flushes of weeds. In organic no-till systems, it is recommended to perform fall tillage prior to seeding the winter rye to better manage perennial weeds and draw down the soil seedbank. This raises the question of whether some tillage in organic no-till systems is simply being offset from the spring to the fall rather than being fully eliminated. It is unknown if a greater frequency of fall tillage prior to seeding winter rye translates to tangible improvements of in-season weed control during the no-till phase of rolled-crimped cover crop systems.

Experimental Design

This experiment took place within an organic reduced tillage soybean system that utilized a rolled-crimped winter rye cover crop for weed suppression. Following harvest of an oats crop, we prepared the field for planting winter rye by establishing a gradient of field cultivation frequencies. In all treatments, except for the no-till treatment, a primary tillage pass was performed with a chisel plow to incorporate residues. After chisel plowing, a gradient ranging from one to four field cultivation passes performed over the period of one month was established with intentions of depleting the soil seedbank.

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In addition to the gradient of tillage passes, we also explored planting a low rate (130 lbs/ac) and a high rate (195 lbs/ac) of winter rye within each tillage treatment to explore if winter rye density impacts weed emergence differently under varying levels of tillage frequencies. This experiment included 10 total treatments *(Table 1)* and was replicated four times in a randomized complete block factorial design.

Table 1. *A list of treatments combinations explored in this experiment by the two studied factors of fall field cultivation frequency and winter rye seeding rates.*

Field cultivation frequency	Winter rye seeding rate	Treatment Name
	lbs/ac	
No-Till	130	No-Till; Low
No-Till	195	No-Till; High
1x Field cultivation (FC)	130	1x FC; Low
1x FC	195	1x FC; High
2x FC	130	2x FC; Low
2x FC	195	2x FC; High
3x FC	130	3x FC; Low
3x FC	195	3x FC; High
4x FC	130	4x FC; Low
4x FC	195	4x FC; High

Objectives

Our objectives were to explore the relationship between fall tillage frequency on the soil weed seedbank and observe whether fall tillage frequency translates to differences in weed biomass during the subsequent no-till phase of the rolled-crimped soybeans. We also sought to explore whether rye planting density impacts weed emergence and whether interactions between rye planting density and fall tillage intensity occur.

Results

Rye Biomass

Winter rye biomass was significantly decreased when no fall tillage occurred with rye being direct seeded into oat stubble *(Figure 1)*. However, frequency of field cultivation passes did not impact rye biomass. Observationally, winter rye was much slower to emerge and develop in the no-till plots *(Figure 2)* likely due to colder soil temperatures and less light penetration through canopies of oat and weed regrowth present in no-till scenarios. Across all treatments, winter rye growth was lower than typically observed at this location and below the optimum level for weed suppression. This was particularly true to the no-till plots in which rye growth was not adequate to ensure weed suppression.

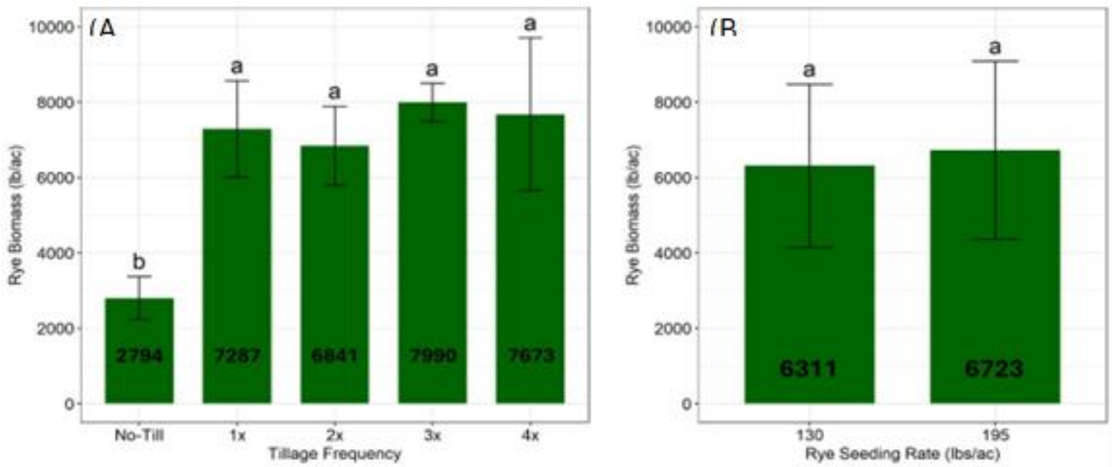

Figure 1. *Winter rye biomass measured at rye anthesis for each (A) tillage frequency and (B) rye seeding rate in the False Seedbed Experiment at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

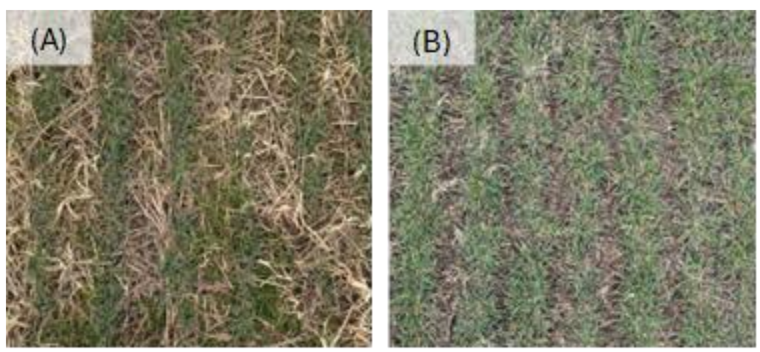

Figure 2. *Winter rye ground coverage in (A) no-till plots and (B) tilled plots on April 10, 2025 in the False Seedbed Experiment located at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

Weed Biomass Weed biomass was measured on August 22nd corresponding with peak weed biomass. Weed biomass was strongly variable across plots and quite high overall *(Figure 3).* No differences were recorded between the low and high rye seeding rate treatments with weed biomass measuring at 1615 and 1340 lbs/ac respectively. By tillage frequency, no-till reported the highest weed biomass which was statistically higher than four passes of field cultivation *(Figure 4a).* These weed biomass results are similar to the number of weeds that germinated in the greenhouse for each frequency of field cultivation passes *(Figure 4b).* Weed communities did differ between the no-till and fall tillage treatments with no-till plots showing a higher proportion of perennial weeds such as dandelion, broadleaf plantain and Canada thistle. Treatments that utilized fall tillage prior to seeding winter rye were more proportionally dominated by Yellow Foxtail (data not shown).

Figure 3. *A comparison of organic rolled-crimped soybean systems with A) no fall tillage prior to seeding winter rye and B) three passes of field cultivation prior to seeding winter rye at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

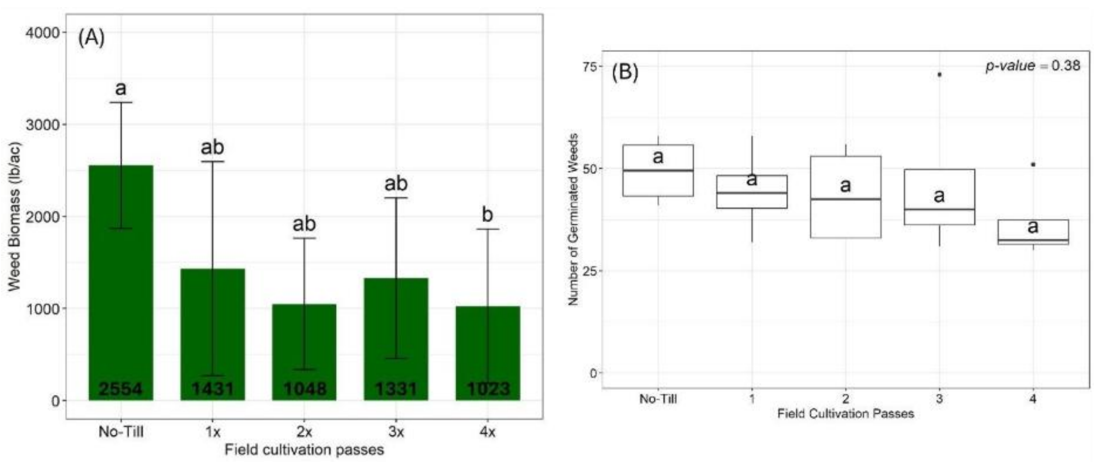

Figure 4. *A) Weed biomass measured on August 22, 2025 and B) the total number of germinated weed seeds measured in a greenhouse by each treatment of field cultivation frequency in the False Seedbed Experiment located at the Arlington Agricultural Research Station, Arlington, WI.*

Soybean yield

Soybean grain yield was relatively low across the experiment due to large amount of weed biomass throughout the study. Soybean yield was significantly lower in the treatments without fall tillage as compared to all levels of fall field cultivation frequencies *(Figure 5)*. These no-till plots only averaged 14 bu/ac representing both the high level of weed biomass present *(Figure 3a)* within these plots but also the increased community of perennial weeds. Perennial weeds that are already established within the rye stand can compete against the soybeans for a greater period of the soybean growing season as compared to annual species that emerge weeks after rye termination. Soybeans yielded an average of 43.8 bu/ac across all frequencies of fall field cultivation due to intense weed pressure within the plots. Soybean yield was not statistically different by the low vs high rye seeding rate treatments averaging 36.9 and 38.8 bu/ac respectively.

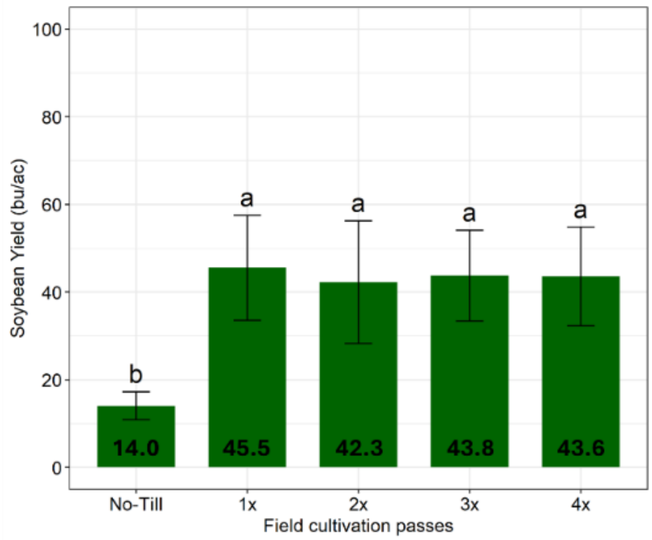

Figure 5. *Soybean grain yield for each frequency of field cultivation passes in the False Seedbed Experiment located at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

Economic analysis

We compared the revenue difference of each treatment to all other treatments using the 1x FC; Low treatment as our baseline treatment to which all other treatments were compared. Unsurprisingly, any plots that were managed without fall tillage experienced steep revenue losses due to low yields despite lower production costs *(Table 2).* At the low rye seeding rate of 130 lbs/ac, there was a trend towards increasing revenues with greater frequency of field cultivation as compared to the 1x FC treatment. Interestingly, at the higher rye seeding rate, we noted an opposite trend where revenues declined with greater frequency of fall field cultivation passes. This shows that revenues were maximized when using either a low seeding rate of rye and increased frequency of fall stale seedbed passes or when using a higher seeding rate of rye paired with fewer field cultivation passes.

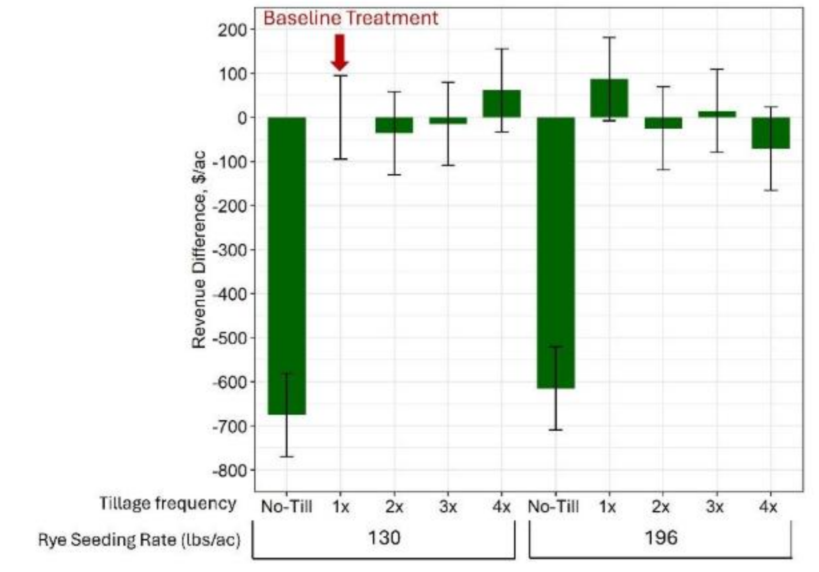

Figure 6. *Revenue differences between each treatment based on the variable costs associated with each treatment in the False Seedbed Experiment located at the Arlington Agricultural Research Station, Arlington, WI, 2025. The 1x tillage frequency at the 130 lbs/ac rye seeding rate was used as the baseline treatment to which all other treatments were compared.*

Table 2. *Variable costs for fuel and rye seed combined to the total variable costs per each treatment. Variable costs indicate only costs that differed between treatments to represent economic differences between treatments and do not reflect all field production expenses. Variable fuel costs represent the estimated gallons per acre to perform a field function multiplied by a diesel fuel cost of $3.00/gal whereas rye seed costs represent the cost of rye seed to seed each treatment at the low and high seeding rate assuming $0.46/lb of organic winter rye seed.*

Treatment Name	Variable fuel costs	Variable rye seed costs	Total variable costs
	--	$/ac	--
No-Till; Low	0.9	59.8	60.7
No-Till; High	0.9	90.2	91.1
1x FC; Low	5.25	59.8	65.1
1x FC; High	5.25	90.2	95.4
2x FC; Low	7.2	59.8	67.0
2x FC; High	7.2	90.2	97.4
3x FC; Low	9.15	59.8	69.0
3x FC; High	9.15	90.2	99.3
4x FC; Low	11.1	59.8	70.9
4x FC; High	11.1	90.2	101.3

Experimental Management

Field Management

Following oat harvest, the field was prepared for seeding winter rye by chisel plowing all treatments with the exception of the no-till treatment. After chisel plowing, secondary tillage occurred with a field cultivator with varying frequencies required for each treatment *(Table 3)* until winter rye seeding. Due to oat and weed regrowth in the no-till plots, mowing was done directly before harvest to limit competitive effects on winter rye germination and growth. Rye was terminated and soybeans were planted in a single pass operation using a planter-attached roller crimper (Dawn ZRX).

Table 3. *Dates of various field management activities together with the treatments impacted by each management activity for the False Seedbed Experiment at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

Date	Management Activity	Treatments Impacted
Aug. 23, 2024	Chisel plowing	All treatments except no-till
Aug. 29, 2024	Field cultivation	4x field cultivation (FC)
Sept. 4, 2024	Field cultivation	3x + 4x FC
Sept. 13, 2024	Field cultivation	2x + 3x + 4x FC
Sept. 19, 2024	Field cultivation	1x + 2x + 3x +4x FC
Sept. 19, 2024	Mowing	Only no-till treatment
Sept. 19, 2024	Planting winter rye	All treatments
June 6, 2025	Crimping rye and planting soybeans	All treatments
Nov. 3, 2025	Soybean harvest	All treatments

Greenhouse Experiment

At winter rye planting, following all fall false seedbed passes, 20 soil cores were collected at a depth of 6” within each tillage frequency plot. This soil was transported to a greenhouse and placed in growth trays and watered to initiate weed germination. All germinated weeds were identified by species (where possible), counted, and removed. Once germination ceased, all soil was cold stratified and later returned to the greenhouse to continue weed germination. This was repeated until no more weeds emerged.

Economic Analysis:
All variable costs for each treatment were calculated. Here, variable costs refer to costs that differed between treatment, but do not represent an accounting of all costs incurred in the experiment. We then made a comparison of revenue differences between treatments by utilizing the 1x FC; Low seeding rate treatment as our baseline and compared the revenue differences of all other treatments to this baseline using the following formula:

Revenue Difference=(Δ Yield x Crop Price)−(Δ Variable Costs)

In this equation:

> **Δ Yield** = The difference in yield of each treatment in relation to the baseline treatment of 1x FC;Low
> **Δ Variable Costs** = the difference in cost between each treatment and the baseline treatment of 1x FC; Low

Variable costs only included differences in fuel usage needed to perform tillage passes and differences in rye seeding rate costs between the low and high rye seeding rates. Fuel costs associated with each tillage pass considered the approximate diesel fuel usage for each field operation (Hanna, 2001) and did not consider other costs associated with the field pass such as machinery wear and tear, depreciation, nor time commitment to perform the operation. For this experiment, we set the cost of diesel fuel at $3.00/gal. Rye seeding costs were the cost of the rye seed for this experiment coming to $0.46/pound of rye seed.

Citations:
Hanna, H. M. (2001). *Fuel required for field operations* (Vol. 571). Ames, IA, USA: Iowa State University, University Extension.

Can we push planting dates earlier in organic no-till soybeans?

Main Takeaways

1. Roller crimping over emerged soybeans did result in soybean plant damage, but the proportion of soybean plants that were killed by the roller crimper was relatively low.

2. Roller crimping when soybeans are in the VE growth stage (hook stage to cotyledons emerged) increased the proportion of plants killed by the roller crimper from 6.2% to 18.6% of the plant stand as compared to waiting until the VC stage (unifoliate leaves emerged).

3. Despite greater damage to soybean plants, yield was optimized by pushing planting dates one week earlier (May 27th) than planting soybeans at mid rye anthesis (June 2nd).

Late planting dates can be a challenge in organic no-till soybean systems

Best management practices have recommended delaying soybean planting in organic no-till soybean systems in which winter rye is being rolled-crimped until rye reaches a stage that adequate termination with a roller crimper can be expected. This ranges from 50% anthesis through early milk development of the grain providing an approximately 10-day window to roller crimper. Crimping too early results in unsuccessful rye termination that competes with soybeans while crimping too late allows for rye seed development that can increase volunteer rye. However, delaying planting until rye anthesis pushes soybean planting dates typically into early June which lowers yield potential through shorter growing seasons and the need to adopt shorter relative maturity soybean varieties. Previous research has suggested that soybean planting dates can be pushed earlier by planting into a standing rye crop and returning after soybean emergence to terminate the cover crop. However, the effects of how planting into a standing rye and roller crimping later effects soybean plant stands and yield remain under researched.

Objectives

In this study our objectives were to establish a range of planting dates prior to rye termination over three weeks and uniformly terminate the rye upon reaching full anthesis to observe the effects on:

- Soybean seedling damage
- Final plant stands
- Soybean grain yield

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Experimental Design

This study created a gradient of three planting dates beginning on May 19th and occurred weekly as weather conditions allowed until rye reached early/mid-anthesis on June 2nd. Rye was then terminated upon full anthesis on June 11. These three planting date treatments were replicated four times in a randomized complete block experimental design at the Arlington Agricultural Research Station in Arlington, WI during the 2025 growing season.

Results

Rye Biomass

Rye growth stages at soybean planting ranged from full heading (Zadoks 59) on May 19th to the beginning of anthesis (Zadoks 61) on May 27th to mid anthesis (Zadoks 65) on June 2nd. Rye biomass averaged 8688 lbs/ac across planting date treatments and did not statistically differ between any of these planting dates likely because full head emergence had already occurred at the earliest planting date and biomass accumulation beyond full head extension through anthesis is not expected (*Figure 1*). Rye biomass did trend higher at the time of roller crimping averaging 9987 lbs/ac which is likely due to rye being terminated in the early milk stages of rye development (Zadoks 71) in which developing grains may have slightly increased total rye mass.

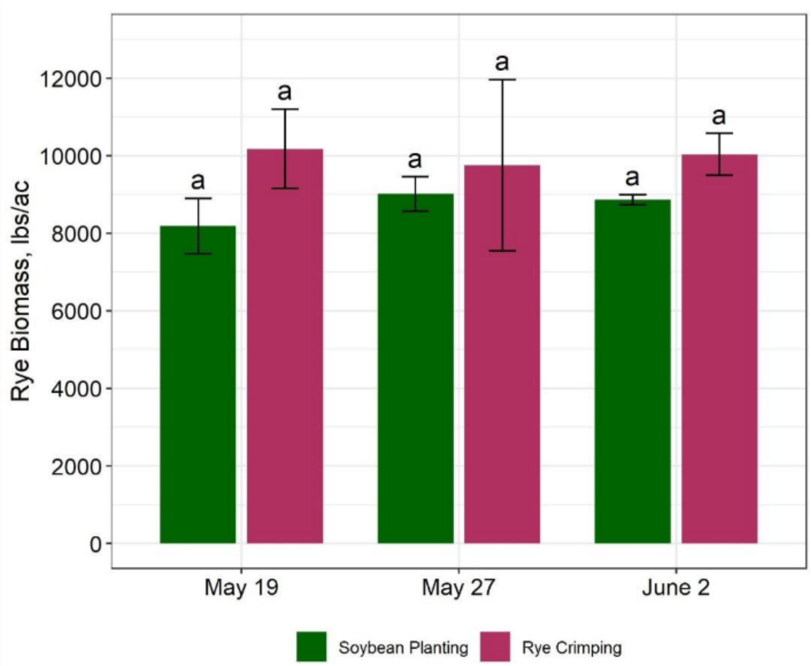

Figure 1. *Winter rye biomass and standard deviation measured at the time of soybean planting across three different soybean planting dates and again at rye termination (June 11) in the roller crimping after soybean emergence study at the Arlington Agricultural Research Station in Arlington, WI, 2025.*

Soybean plant damage by roller crimping

Roller crimping over emerged soybean plants did increase soybean plant damage (*Figure 2*) with 90% of seedlings unaffected by crimping when soybeans were planted 9 days prior to crimping and most plants had not yet emerged as compared to only 55% of plants being unaffected when planting on May 27th. The May 19th planting date showed 65% of plants being unaffected which did not differ statistically from either of the other treatments. The proportion of plants that were bent or crimped did not differ between the May 19th or May 27th planting dates. However, the number of plants that were killed by the roller crimper (cut and dead plants) did increase significantly at the May 27th planting date as compared to the May 19th or June 2nd. The May 27th planting date had 18.6% of terminated plants vs 6.8% at the May 19th date and only 2.7% at the June 2nd date. This difference between the May 19th and May 27th planting dates is likely related to the soybean growth being predominantly in the VE (hook stage to full cotyledon emergence) when being roller crimped at the May 27th date as compared to the VC stage (unifoliate leaves fully emerged) for the May 19th treatment. Previous observations have shown that roller crimping over soybeans at the hook stage when plant stems are more brittle can cause damage to seedlings and stand loss. After unifoliate leaves emerge, soybean plant stems become more pliable, limiting cutting of plant stems but can still result in bending or crimping of plants.

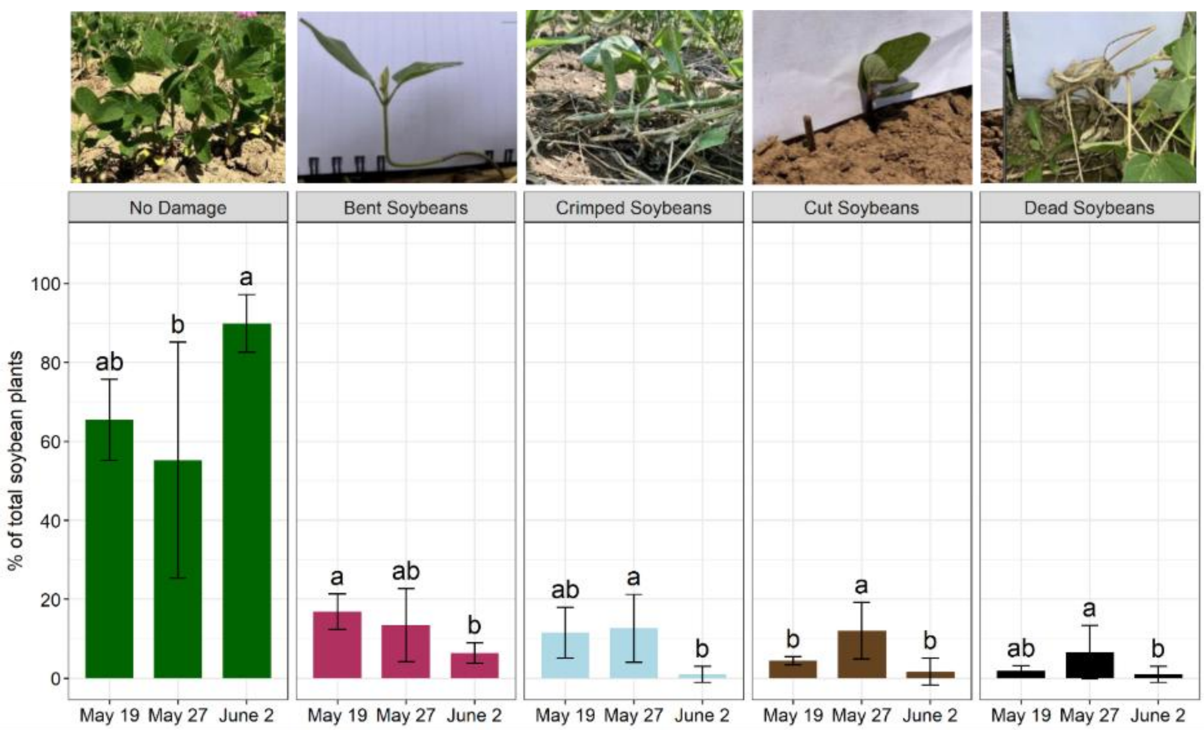

Figure 2. *A comparison of different soybean damage categories presented with standard deviation observed by planting date treatment in the roller crimping after soybean emergence study located at the Arlington Agricultural Research Station, Arlington, WI, 2025. Photographs above each damage category are representative of the type of damage indicated by each category. Photographs provided by Ana Roldan, Cornell University.*

Weed biomass

In late July we measured the total mass of winter rye that was not successfully terminated by the roller crimper. Later, in mid-August corresponding with peak weed biomass, we measured total weed biomass in the plots to understand competition dynamics. Weed biomass was highly variable across plots and was observed to be statistically higher at the May 27th planting date as compared to the June 2nd planting date (*Figure 3*). While not statistically different from each other either other treatment, the May 19th planting date did have numerically higher weeds than the June 2nd treatment. Likewise, total rye regrowth, while not differing statistically between treatments did show a linear trend towards decreasing as planting date was delayed closer to termination of rye (*Figure 3*). The mechanisms behind the trend towards greater unterminated rye at earlier planting dates is not completely understood but may be related to damage inflicted on the rye the planter tires and planter which may developmentally set back some of the rye making it less susceptible to termination or through possibly initiating new tillers from the base of the plant that are not well controlled by roller crimping. The increase in weed biomass at the May 27th planting date may be in part related to lower plant stand with this treatment from greater seedling damage or could also be influenced by less uniform rye termination at these earlier planting dates.

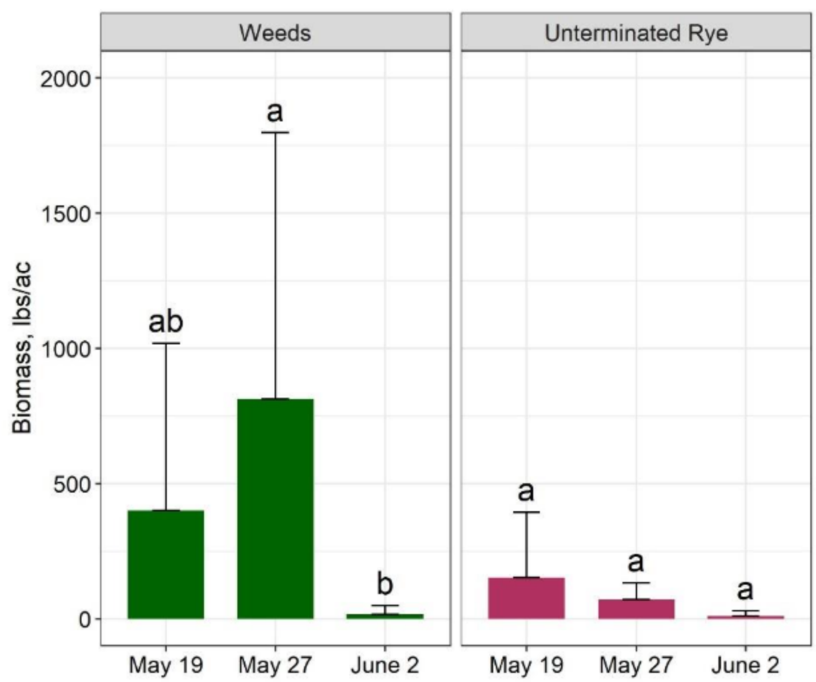

Figure 3. *Biomass of weeds and unterminated rye presented with standard deviation for three soybean planting date treatments in the roller crimping after soybean emergence study located at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

Soybean yield and lodging

Soybean yields reported in this study are exceptionally high averaging 88.4 bu/ac across treatments (*Figure 4A*). After careful consideration of the results and review of methodologies, we do believe that these soybean yields estimated from these plots are real, though perhaps an overestimation, of the true yield of these plots. These plots were hand harvested and therefore were not subject to potential harvest losses which may slightly lower yield estimations. Despite the harvest methodology, comparison of these yield results with other no-till soybean experiments that were combine harvested within the same field lead us to believe that the results presented here are realistic. In addition, a soybean variety trial done at the Arlington Agricultural Research Station during 2025 included the same variety used in this experiment which yielded 98 bu/ac (Conley et al., 2025). While this variety trial was managed under conventional practices, the results show a high yield ceiling at this site.

When comparing yield across treatments we noted that the May 27th planting date did yield significantly higher than the June 2nd planting date (*Figure 4A*). This suggests that pushing planting dates earlier than mid anthesis may promote improved soybean yield through a longer growing season despite observed plant stand reductions and even higher weed biomass with the May 27th planting date as compared to the June 2nd treatment. Interestingly, the May 19th planting date did not yield differently than the May 27th treatment despite an eight-day earlier planting date and lower seedling mortality from the roller crimper. The mechanisms behind this are not fully understood; however, increasing the time in which plants are growing underneath the canopy of winter rye may also reduce the yield potential of the crop although more research is needed to verify these results. The results of this one-year study suggest a potential sweet spot of roller crimping once soybeans reach the late VE to early VC growth stages to limit damage to plant stand while decreasing the time in which soybeans are growing underneath the rye canopy.

A visual examination of soybean lodging showed greater soybean lodging on the May 19th date as compared to the May 27th and June 2nd planting dates (*Figures 5B, 6)*. It's possible that delaying roller crimping until soybeans are more advanced in development may have a greater effect on bending plant stems which could increase lodging potential. The May 19th planting date had numerically the greatest number of bent soybean stems, although it did not differ statistically from the May 27th planting date. More data is needed to see if this trend is replicated in future years.

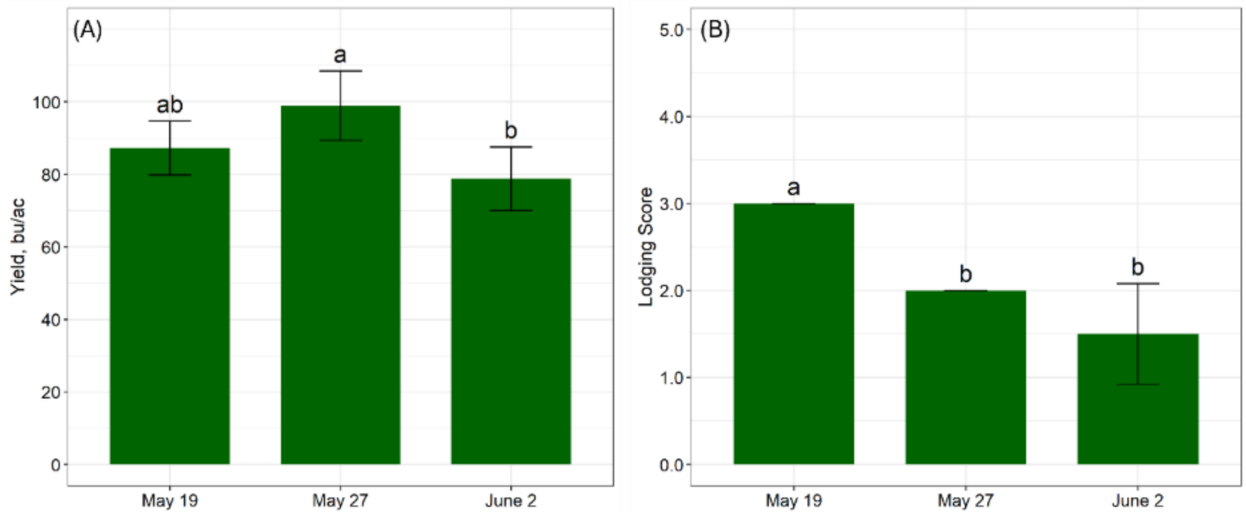

Figure 5. *Soybean grain yield and lodging scores presented with standard deviation by three soybean planting date treatments in the roller crimping after soybean emergence study conducted at the Arlington Agricultural Research Station, Arlington, WI, 2025. Soybean lodging scores are interpreted in the following manner: 1 = Almost all plants erect, 2 = All plants leaning slightly or a few plants down, 3 = All plants leaning moderately or 25-50% of plants down, 4 = All plants leaning considerably or 50-80% of plants down, 5 = all plants down.*

Figure 6*. Photographs representing soybean lodging observed at each soybean planting date in the roller crimping after soybean emergence study located at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

Crop Management

All crop management activities are listed in Table 1. In short, rye (v. ND Gardner) was sowed in mid-September into a field that had been tilled to incorporate manure and prepare a clean, weed-free seedbed. A range of soybean planting dates were initiated on May 19th, and soybeans (v. BR 2418N) were seeded at a rate of 225,000 pure live seed/ac into standing rye. Upon rye completing anthesis, it was roller crimped and terminated. Soybeans were harvested in late October.

***Table 1**. Crop management activities and dates for the roller crimping after soybean emergence study located at the Arlington Agricultural Research Station, Arlington, WI, 2025.*

Date	Management activity
Sept. 19, 2024	**Winter rye sowing**
May 19, 2025	**Soybean planting in first planting treatment**
May 27, 2025	**Soybean planting in second planting treatment**
June 2, 2025	**Soybean planting in third planting treatment**
June 11, 2025	**Winter rye termination with roller crimper**
Oct. 26, 2025	**Harvested all plots**

The following data was collected:

- Rye biomass and rye growth stages at soybean planting for each treatment effected.
- Rye biomass along with rye and soybean growth stages at rye termination (June 11th)
- Soybean stand counts and damage assessments (June 17th)
- Unterminated winter rye biomass assessment (July 29th)
- Weed biomass (August 28th)
- Soybean yield (October 26th)

Citations

Conley, S. P., Roth, A. C., Kendall, M., Smith, D. L. (2025). 2025 Wisconsin Performance Trials. A3654. University of Wisconsin- Madison.
https://badgercropnetwork.com/wp-content/uploads/2025/10/WI-soybean-booklet-25-Web.pdf

UW-Madison's work on planter improvements for no-till organic systems

Soybean emergence continues to be problematic in organic no-till systems

Planting into high biomass cover crop scenarios continues to present a challenge for farmers. When managing organic no-till soybeans through roller crimping, winter rye biomass in excess of 8,000 lbs/ac is often needed to increase the likelihood of weed suppression. However, this dense mulch disrupts soybean seed placement resulting in variable seeding depths and, at times, inadequate planter ground penetration particularly under dry soil conditions. Soybean yields tend to increase with soybean plant stand up to a point before beginning to level off due to remarkable plasticity in soybean plant growth in which greater plant branching compensates for lower plant stands. However, soybean plant density also aids in weed suppression which has driven up economically optimal seeding rates in organic systems to above 200,000 seeds/ac. Improving soybean seed establishment in high residue organic no-till systems through planter set-up improvements represent a cost savings measure for farmers to achieve similar final plant densities at lower seeding rates.

What has our previous research shown?

Previous research at UW-Madison has shown that increasing down pressure (300 lbs/row unit) can improve soybean plant stands in some cases, particularly where rye biomass is greater than 10,000 lbs/ac or under dry soil conditions. However, increased down pressure can show tradeoffs that reduce plant stand under some circumstances linked to increased hairpinning and side wall compaction under wet soil conditions or in fine textured soils *(Figure 1).* Additionally, planter-attached coulters can help cut rye residues and penetrate the soil ahead of the opening discs. Evaluations of coulter types at UW-Madison has shown that straight coulters have improved soybean seed placement as compared to fluted coulters *(Figure 2).*

Research directions for 2025

During this growing season, we aimed to push forward the work to understand ideal planter set-up and management to improve soybean establishment in no-till systems. In one study we aimed to compare a newer serrated disc opener which we hypothesized may offer some benefits in residue cutting in combination with coulters to improve seed placement. We sought to explore this disc opener in combination with other planter components such as coulters and down force level to understand tradeoffs between planter components. In a separate experiment we looked into a common farmer question regarding the order of planting and roller crimping. Does planting prior to crimping offer benefits to soybean plant stand over roller crimping and planting in a single pass operation? The following reports demonstrate our findings for these studies during the 2025 growing season.

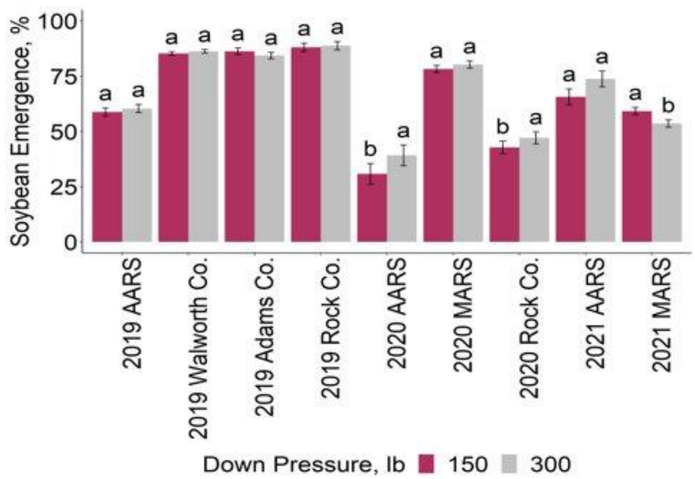

Figure 1. *Comparison of soybean emergence percentage by two levels of planter down pressure measured at nine locations from 2019-2021*

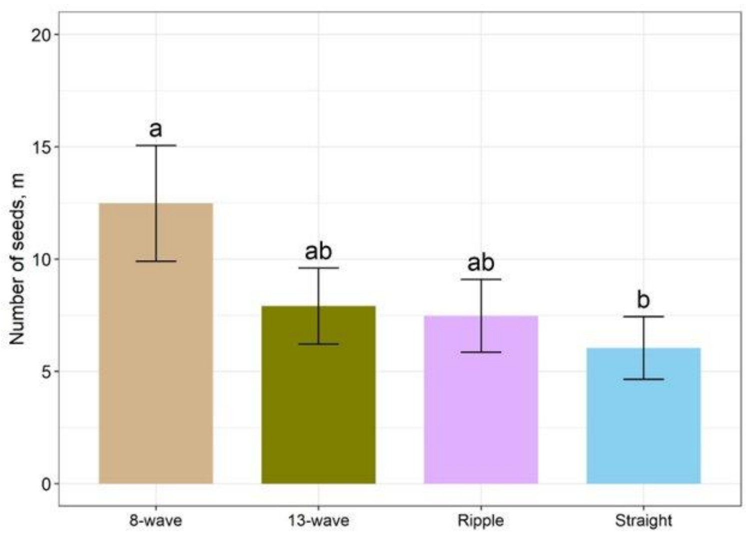

Figure 2. *The number of soybean seeds placed outside of the planter furrow by four styles of planter attached coulters at the Arlington Agricultural Research Station, 2022-2023.*

Comparing serrated vs smooth planter openers

Main Takeaways

1. Serrated double disc openers did not change soybean plant stand or grain yield as compared to standard smooth double disc openers.

2. The serrated opening disc lowered hairpinning by 9.6% compared to smooth double disc opener.

3. A straight coulter lowered the number of soybean seeds placed outside of the crop furrow by 1 seed/foot of row (17,000 seeds/ac) as compared to no coulter.

Evaluation of planter opening discs

What were our objectives?

Serrated opening discs are designed to help fracture the furrow side wall in no-till settings and could have an added benefit of improving residue cutting in high residue no-till conditions. These opening discs remain untested under organic no-till systems with rolled-crimped cover crops. Our objectives were to:

1. Explore whether serrated opening discs improved seed placement, soybean stand, or yield.
2. Explore how opening disc style interacts with other important planter components such as down pressure and coulters.

Experimental Design

We compared serrated and standard smooth double disc openers under low (200 lb/row unit) and high (450 lb/row unit) down pressure settings both with and without a coulter attachment. Each opening disc was paired in all combinations with other tested planter components of coulter and down pressure resulting in eight unique treatment combinations. Each treatment was replicated four times in a factorial randomized complete block design. This study was conducted at the Arlington Agricultural Research Station in a certified organic system in which soybeans were direct seeded into a rolled-crimped winter rye cover crop

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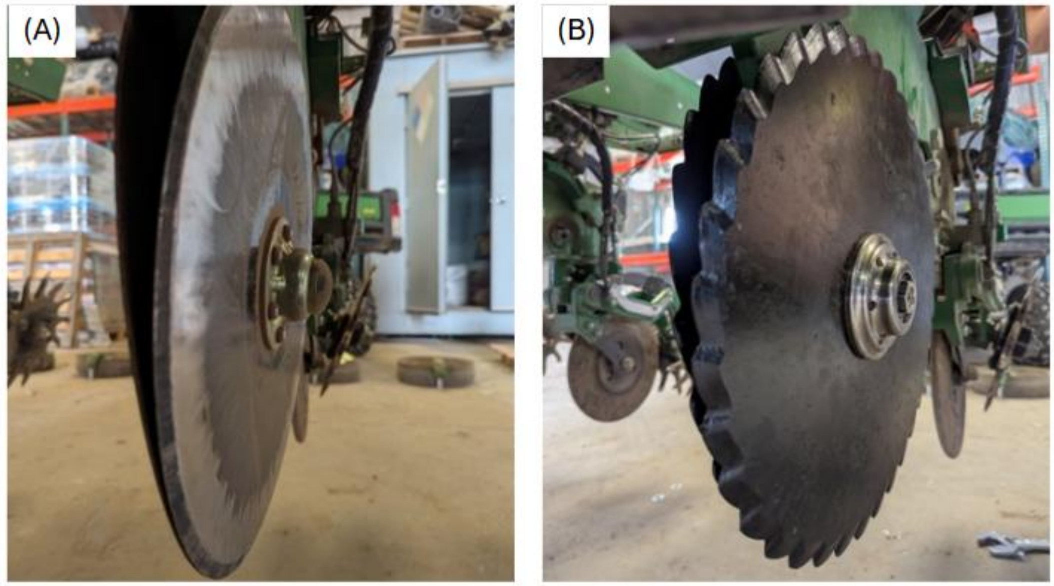

Figure 1. *Two styles of planter openers used in this experiment comparing A) smooth and B) serrated double disc opening wheels*

Results

Site Description

Rye biomass at the time of termination was 10,155 lbs/ac. Precipitation surrounding soybean planting was near historical averages with soil moisture at a 1.5" depth measured at planting time reported at 16.9%

Soybean Seed placement

When examining each opening wheel design averaged across all combinations of coulter and down pressure, we observed a 9.6% decrease in hairpinning when using the serrated opening disc suggesting improved residue handling over a smooth opening disc. Coulter use lowered the number of soybean seeds outside of the furrow or caught up in rye mulch suggesting improvements in seed placement as compared to not using a coulter. This result matches our previous experience in rolled-crimped systems. The amount of down pressure did not influence any indicator of soybean seed placement.

Soybean performance

Despite some observed differences in seed placement, no planter component that we tested influenced soybean plant stand or grain yield. Plant stand was relatively high averaging 143,560 plants across the experiment representing a soybean establishment rate of 71.8% when accounting for 90% germ seed. When each treatment combination was analyzed individually, no statistical differences were reported in either plant stand or grain yield *(Figure 2).*

Table 1. *Treatment means for the three factors of Opening disc, coulters, and down pressure in the Planter Opener experiment, Arlington, WI, 2025. Means with letters represent statistical difference within each factor at a p < 0.1 significance level.*

	Surface Seeds†	Hairpinning	Soybean plant stand	Weed biomass	Soybean yield
	seeds/ft	%	plants/ac	lbs/ac	bu/ac
Opening Disc					
Serrated	1.27	**24.2 b**	144,523	454	60.4
Double disc	1.38	**33.8 a**	142,594	455	60.8
p-value	*0.61*	***0.09***	*0.65*	*0.99*	*0.86*
Coulter					
Straight coulter	**0.83 b**	30.2	144,305	506	60.3
No coulter	**1.82 a**	27.8	142,812	403	60.9
p-value	***<0.001***	*0.67*	*0.73*	*0.25*	*0.83*
Down Pressure					
200 lbs	1.50	26.4	146,732	529	61.2
450 lbs	1.14	31.6	140,385	380	60.0
p-value	*0.10*	*0.35*	*0.15*	*0.11*	*0.64*

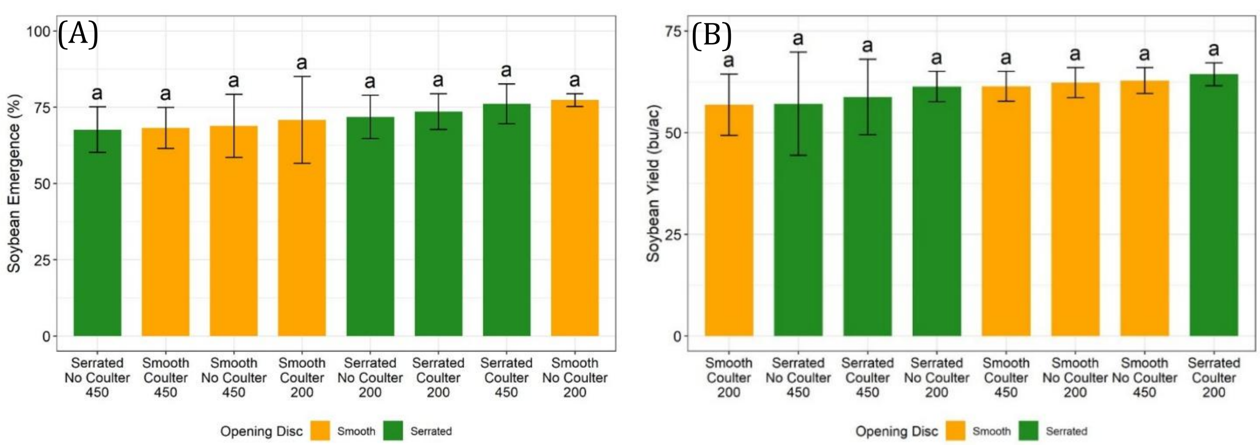

Figure 2. *Soybean (A) emergence percentage and (B) grain yield presented with standard deviation for each individual treatment combination of the Planter Opener Experiment located at the Arlington Agricultural Research Station, Arlington, WI. 2025. Results are color coded by opening disc design.*

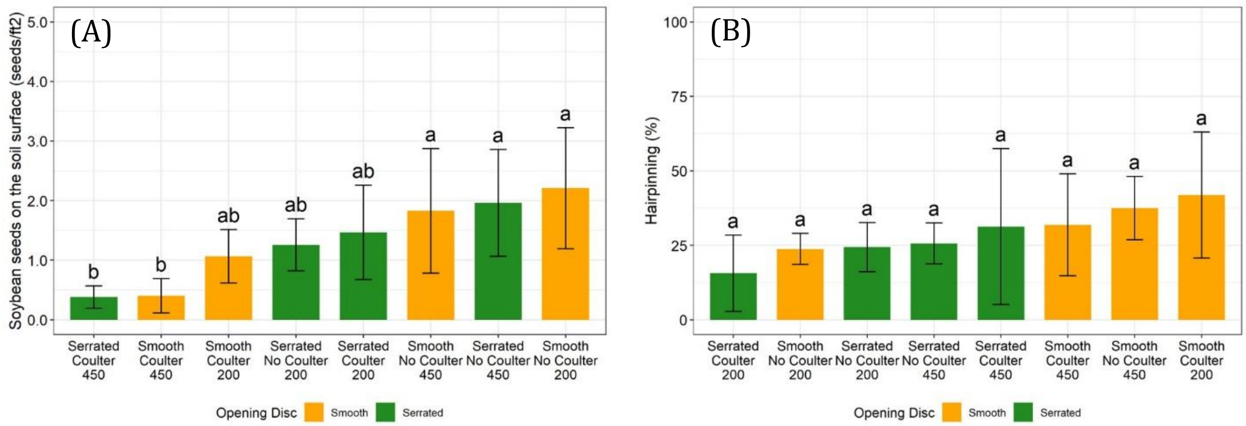

Figure 3. *(A) The number of soybean seeds on the soil surface and not in the planter furrow and (B) percent of hairpinning observed in the furrow presented with standard deviation for each individual treatment combination of the planter Opener Experiment located at the Arlington Agricultural Research Station, Arlington, WI, 2025. Results are color coded by opening disc design.*

Crop management

Crop management activities for this experiment are listed in *Table 2.* Liquid dairy manure was applied at a rate of 12,000 gal/ac on August 30th. Winter rye (v. ND Gardener) was seeded at 3 million pure live seeds/ac (200 lbs/ac). Soybeans were direct seeded into a rolled-crimped cereal rye using a roller crimper (McFarlane Manufacturing) and a John Deere planter (model 7000 with Max Emerge XP row units) that was equipped with hydraulic down force. A seed firming wheel and solid rubber closing wheels were attached behind the disc openers. Crimping and planting occurred in a single pass operation with a front mounted roller crimper and rear mounted planter.

Table 2. *Crop management activities for the Planter Opener study located at the Arlington Agricultural Research Station in Arlington, WI, 2025.*

Management Activity	No-Till Soybeans	Tilled Soybeans
Winter rye planting	Sept. 19, 2024	Sept. 19, 2024
Rye termination and soybean planting	June 13	June 13
Harvest	October 27	October 27

Data Collection:

- Rye biomass, soybean surface seeds, hairpinning – June 13th
- Soybean stand counts – July 2nd
- Weed biomass – September 10th
- Soybean grain yield – October 27th

Comparing planting strategies: Does planting before crimping improve soybean emergence?

Main Takeaways

1. The order of planting soybeans and roller crimping did not impact soybean plant stand; however, planting prior to crimping did trend towards higher plant stands in this one-year study.

2. Soybean yield did not differ by whether planting occurred before or after roller crimping winter rye.

3. No-till soybeans trended towards greater yields, though were not statistically different than cultivated soybeans averaging 60.4 and 54.5 bu/ac respectively.

Context to the Experiment

To plant or roller crimp first? What are the tradeoffs?

Planting into dense stands of cover crops can be technically challenging. Planter penetration through cover crop biomass can hamper soybean seed placement. Historically, our research has focused on planting and roller crimping in a single pass operation using either a front mounted roller crimper or a roller crimper attached to the planter frame (Dawn Manufacturing ZRX crimpers). However, many organic farmers prefer to plant soybeans first and crimp in a secondary pass. The decision to plant soybeans directly into standing cover crops before roller crimping may offer benefits in seed placement and soybean plant stand but requires a secondary field pass. There have been minimal comparative studies seeking to explore differences in soybean seed placement, plant stand, and grain yield when comparing the order of planting and crimping in organic rolled-crimped soybean systems.

Experimental Design:

We implemented two planting strategies *(Figure 1)* which compared 1) Planting soybeans into standing rye and roller crimping in a secondary pass (Plant First) with 2) Roller crimping with a front mounted crimper and planting in a single pass operation (Crimp First). These two no-till systems were compared to planting soybeans into a standard tillage-based system using in-season row cultivation to control weeds. All treatments were replicated four times in a randomized complete block design at the Arlington Agricultural Research Station in 2025.

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Both the Plant First and Crimp First treatments utilized a straight coulter paired with 450 lbs of down force per row unit. The cultivated treatment lowered down force to 200 lbs/row unit and did not use a coulter. All treatments used double disc openers and spiked closing wheels.

Figure 1. *(A) Planting soybeans into standing winter rye (Plant First treatment) and (B) Planting into a rolled-crimped rye using a front mounted crimper (Crimp First treatment). These Photos were not taken from this research experiment but represent the management of each experimental system.*

Results

Soybean seed placement.

We did not observe any difference in the number of soybeans seeds that were not placed within the planting furrow between the Plant First and Crimp First treatments *(Table 1).* Both systems performed exceptionally well in placing seeds into the furrow with only an average of 0.37 soybean seeds found per foot of row length indicating only 2.9% of the targeted seeding rate of 225,000 seeds/ac did not reach the furrow. Hairpinning was relatively high in this experiment with rye residues found within approximately 30% of the furrow. However, this amount did not differ by planting strategy.

Soybean plant stands and grain yield.

Plant stands trended higher using the Plant First method by 17,600 plants/ac, but this was not deemed to be statistically different *(Table 1).* Plant stands in the cultivated system more closely mirrored the Plant First treatment. The Plant First system had 77% compared to a 68% establishment of the Crimp First treatment compared to the target seeding rate (when accounting for 90% germ seed).

Soybean yield was excellent within no-till systems averaging 60.4 bu/ac but not expressing any statistical differences between the Plant First and Crimp First treatments. Yields did trend higher in the two no-till systems as compared to the cultivated system which was likely a result of higher weed pressure observed in the tillage-based system *(Table 1).* Weeds were well managed by the rolled-crimped rye averaging 470 lbs/ac of weed biomass as compared to over 2000 lbs/ac of weed biomass observed in the cultivated system.

Table 1. *Treatment means comparing two strategies of no-till planting soybeans into cereal rye compared to a standard tillage-based cultivated system (Cultivated). No-till planting strategies included 1) Planting first and roller crimping later in a secondary pass (Plant First), 2) Roller crimping first and no-till planting in a single pass operation (Crimp First). The experiment was conducted at the Arlington Agricultural Research Station, 2025. Means with letters represent statistical difference within each factor at a p < 0.1 significance level.*

	Surface Seeds†	Hairpinning	Soybean plant stand	Weed biomass	Soybean yield
	seeds/ft	%	plants/ac	lbs/ac	bu/ac
Crimp First	0.40 ± 0.15	31.9 ± 9.31	136,402 ± 6500	339 ± 520 b	61.4 ± 2.56
Plant First	0.34 ± 0.15	28.8 ± 9.31	154,075 ± 6500	602 ± 520 ab	59.3 ± 2.56
Cultivated	--‡	--	151,835 ± 6500	2275 ± 520 b	54.5 ± 2.56
p-value	0.81	0.83	0.19	0.08	0.23

† The number of soybean seeds on the soil surface or caught up in rye mulch layers.
‡Parameters were not measured in the C system due to the lack of surface residues.

Practical Implications of results
The decision to plant or crimp first often depends on the level of comfort that any farmer has in the ability of their planter to penetrate through the mulch and into the soil. Factors that may play into this are soil conditions at the time of planting, the amount of rye biomass present, and the physical capabilities of the planter.

In the context of our experiment, the planter was well equipped to handle high residue scenarios which likely limited any differences between the Plant First and Crimp First treatments. More differences in plant stand could be expected under very dry soil conditions or in cases where a planter does not have sufficient weight or down force to effectively penetrate both the mulch and soil. An additional consideration is the number of soil engaging units on the planter. If a planter is running coulters or starter fertilizer discs, the additional soil engaging units will require greater vertical loads and draft requirements which may limit the effectiveness of the seed opening discs in uniformly penetrating the soil and placing seeds.

Crop management

Crop management activities for this experiment are listed in *Table 2.* Liquid dairy manure was applied at a rate of 12,000 gal/ac on August 30th. Winter rye (v. ND Gardener) was seeded at 3 million pure live seeds/ac (200 lbs/ac) and was terminated in the tillage-based plots on May 9th. Soybeans were direct seeded into a rolled-crimped cereal rye using a roller crimper (McFarlane Manufacturing) and a John Deere planter (model 7000 with Max Emerge XP row units) that was equipped with hydraulic down force. A seed firming wheel and solid rubber closing wheels were attached behind the disc openers.

Table 2. *Crop management activities for the Plant vs Crimp First experiment located at the Arlington Agricultural Research Station in Arlington, WI, 2025.*

Management Activity	No-Till Soybeans	Tilled Soybeans
Winter rye planting	Sept. 19, 2024	Sept. 19, 2024
Rye termination/Stale seedbed	--	May 9 June 11
Soybean planting	June 13	June 13
Blind cultivation	--	June 20[a]
Row cultivation	--	June 29 July 3 July 10 July 21
Harvest	October 27	October 27

[a] Rain events limited the frequency of blind cultivation passes. We switched to a row cultivator at the soybean V1 growth stage to aid in controlling emerged weeds.

Data Collection:

- Rye biomass, soybean surface seeds, hairpinning – June 13th
- Soybean stand counts – July 2nd
- Weed biomass – September 10th
- Soybean grain yield – October 27th

Soybean yield response following corn interseeding with cover crops

Main Takeaway

1. Interseeding cover crops into 60" corn as compared to a standard 30" cultivated corn system lowered corn grain yield but did not have any yield effects on the following year's soybean crop.

Background

Interseeding cover crops into corn offers a strategy to integrate cover crops with corn throughout the growing season providing potential improvements to soil health, greater diversity, and an opportunity for value added forage for livestock grazing following corn harvest. Wide row corn is one management strategy to incorporate cover crops by increasing the width of corn, typically to 60", and allowing greater sun penetration to the interseeded cover crops allowing for more biomass accumulation. Previous work at UW-Madison has shown moderate yield declines between 10-30% when growing wide row corn interseeded with cover crops as compared to standard 30" cultivated corn. Some of this lost revenue potential may be recovered in the short term if the cover crop can be utilized as a forage. However, whether these yield impacts of interseeding cover crops extend to the following crop remain unknown.

Experimental Design

60" corn was grown during the 2023 growing season and compared four mixes of cover crops *(Table 1)* as compared to a standard cultivated 30" corn system. The following year, 2024, this field rotated to a cultivated soybean field. We maintained the plot boundaries from the previous year's corn study and harvested soybeans within each plot to understand whether any legacy effects from interseeding cover crops in corn presented themselves in the subsequent year's soybean yield.

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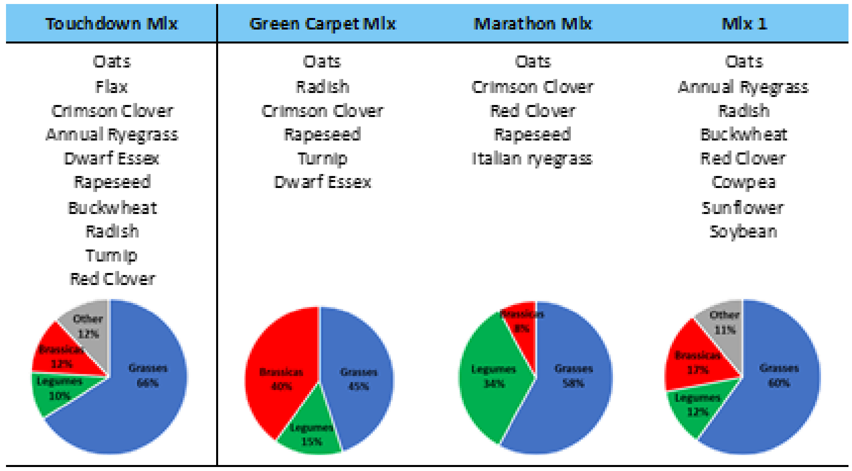

Figure 1. *Seed composition along with the relative contribution of functional groups represented within four cover crop mixtures used to interseed into 60" corn at the Arlington Agricultural Research Station in Arlington, WI, 2023.*

Results

Soybean yield did not differ between any of the previous year's interseeded mixtures. Soybeans also did not yield differently between the 30" corn system and the 60" corn interseeded systems *(Figure 2A).* Despite observing a 27% decrease in corn grain yield the previous year when comparing 60" corn with interseeded cover crops to a standard 30" cultivated corn system *(Figure 2B),* these effects on yield did not appear to extend past the corn phase of the rotation.

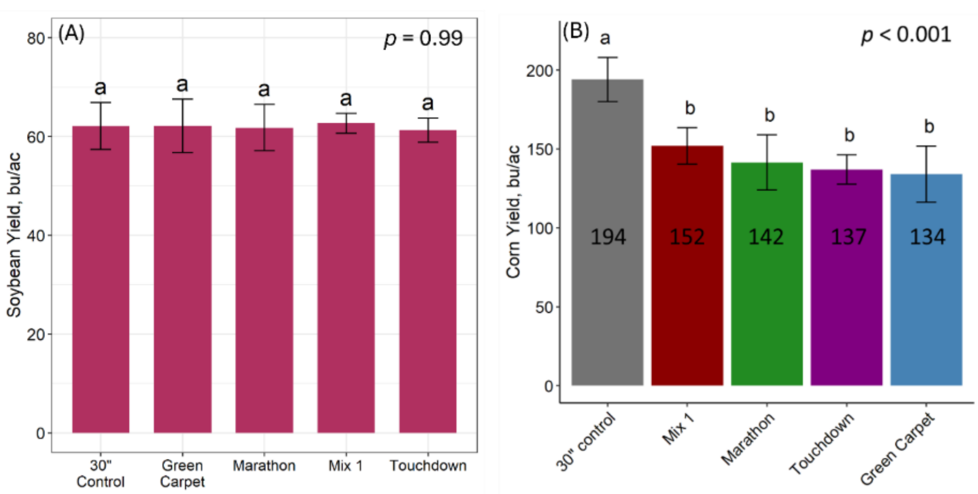

Figure 2. *Results of cash crop grain yield where cover crops were interseeded on 60" corn rows and compared to a 30" cultivated corn system for A) soybeans grown the year after cover crops were interseeded in 2024 and B) corn grown together with the cover crops in 2023. This research study was performed at the Arlington Agricultural Research Station, Arlington, WI, 2023-2024.*

Crop Management

Following corn grain harvest in 2023 from both the 60" corn with interseeded cover crops and the standard 30" corn without cover crops, all plots were chisel plowed in early December to incorporate residues. The following spring, a series of false seedbed passes were implemented to manage the soil weed seedbank. Soybeans (v. BR0821N) were seeded at 225,000 seeds/ac in early June. Weeds were managed throughout the growing season using standard mechanical cultivation practices.

Table 1. *Dates of field management activities for soybeans following an interseeded corn study to explore legacy effects of management on soybean production. This study was performed at the Arlington Agricultural Research Station with interseeded cover crops grown in corn in 2023 and soybeans following in 2024.*

Date	Management activity
Dec. 4, 2023	Chisel plowing
May 14, 2024	Field cultivation
June 6, 2024	Field cultivation
June 7, 2024	Field cultivation
June 7, 2024	Planted soybeans
June 11, 2024	Tine weeding
June 18, 2024	Tine weeding
June 26, 2024	Row cultivation
July 1, 2024	Row cultivation
July 9, 2024	Row cultivation
July 17, 2024	Row cultivation
Sept. 26, 2024	Harvest

Managing corn in an alfalfa living mulch

Main Takeaways:

1. Corn yields in study did not exceed 45 bu/ac under any experimental management strategy despite near optimal growing conditions.

2. Starter fertilizer of 25 lbs N/ac improved corn yields by 20.3 bu/ac over no starter fertilizer application.

3. Interrow mowing alfalfa in-season lowered alfalfa and weed biomass but did not translate to improvements in corn yield.

Background

Using cover crops as a weed suppressive tool allows for the reduction of tillage in organic systems. Living mulch systems are one strategy of reducing tillage in organic corn, but finding an appropriate living mulch pairing with corn is essential to limit competitive effects. Alfalfa may be an attractive option as a living mulch system due to its frequent use in crop rotations and the option to direct seed into an alfalfa stand rotating into corn, thereby eliminating the need for a full width tillage pass to terminate it. Further, there may be an option to gain an additional cutting of alfalfa before seeding corn increasing the value of the system. Despite this, corn yield reductions have frequently been observed in past studies at UW-Madison when strip-tilling into an established alfalfa stand and planting corn concurrently with an alfalfa living mulch. There is a need to further understand the sources of these yield reductions and clarify management practices that promote successful corn production within these systems.

Experimental Design

We explored three experimental treatment factors including 1) forage harvesting alfalfa prior to seeding corn vs No forage harvesting, 2) applying 25 lb N/ac of starter fertilizer at planting vs no starter fertilizer, 3) in-season interrow mowing of alfalfa occurring at corn emergence, the V1, and V5 corn growth stages vs no interrow mowing (Figure 1). Each of these experimental factors were combined with each other across all possible combinations for a total of eight unique treatments. Each treatment combination was replicated four times in a randomized complete block factorial design located at the Arlington Agricultural Research Station in Arlington, WI during the 2025 growing season.

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Objectives

In this study we sought to understand whether:

1. Forage harvesting alfalfa prior to planting corn, while allowing for an additional cutting of alfalfa, has any impact on corn growth or yield.

2. Starter fertilizer applications at planting influence corn grain yield indicating whether nitrogen is limiting in this system.

3. Interrow mowing successfully reduces alfalfa and weed biomass contributing to effects on corn yield.

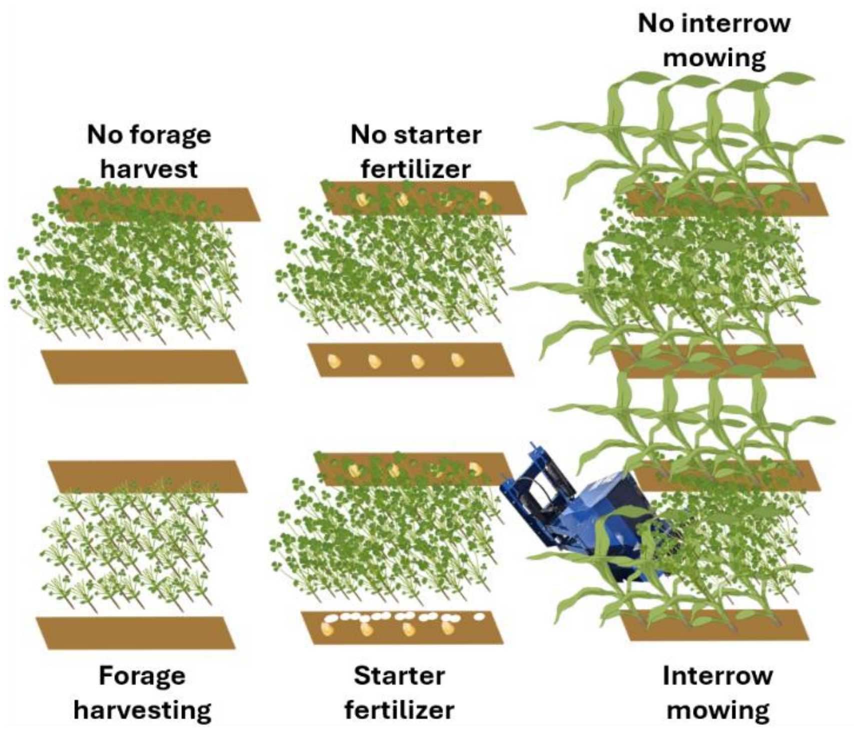

Figure 1. *Graphical representation of the three experimental factors compared in the living mulch alfalfa experiment including 1) forage harvesting vs no forage harvesting before corn planting, 2) 25 lbs N/ac of starter fertilizer vs no starter fertilizer at corn planting, and 3) interrow mowing vs no interrow mowing at corn emergence, V3, and V5 growth stages. This figure was made in part using BioRender images* [*https://BioRender.com*](https://BioRender.com)

Results

Alfalfa and weed biomass

Alfalfa biomass was reported at 1684 lbs/ac with weed biomass being quite high at 2231 lbs/ac when measured at corn planting. In this 4-year-old stand of alfalfa, perennial weeds, particularly dandelion and quackgrass, had moved into the alfalfa stand with the alfalfa showing signs of a thinning stand. When measured again in early September, the alfalfa stand had reduced dramatically across treatments *(Table 1)* and showed signs of senescing with weed biomass remaining high. Weeds at this time were primarily perennial weeds that had grown alongside the alfalfa from early in the season and only a few annual weeds that sprang up in the strip tilled planting strip were observed. However, use of the interrow mower in early stages of corn development did successfully reduce alfalfa biomass and had a slight but statistically significant reduction in weed biomass when measured in September *(Table 1).*

Table 1. *Treatment means for the three experimental factors of forage harvesting, starter fertilizer, and interrow mowing on initial and final corn plant stands as well as alfalfa and weed biomass measured in early September.*

Effect	**Initial corn stand†**	**Final corn stand**	**Alfalfa biomass**	**Weed biomass**
	-------------plants/ac-------------		-------------lbs/ac-------------	
Forage Harvest				
Forage Harvested	37,151	35,782	185	1355
Not Forage Harvested	37,711	34,040	153	1364
Interrow Mowing				
Interrow Mowed	37,836	**36,093 a**	**99.9 b**	**1229 b**
No Mowing	37,027	**33,729 b**	**238 a**	**1490 a**
Starter Fertilizer				
25 lbs N/ac	36,965	34,600	192	1344
0 lbs N/ac	37,898	35,222	146	1375

† Initial corn stand measured at the corn V3 growth stage while final corn stand measured at harvest.

Figure 2. *Planting corn into (A) forage harvested alfalfa and (B) standing alfalfa in the living mulch corn study at Arlington Agricultural Research Station, Arlington, WI, 2025.*

Corn plant stand

Corn was seeded at 40,000 seeds/ac with excellent emergence across all treatments *(Table 2).* There was a slight reduction in corn plant stand by harvest. Most notably, we observed a decrease where no interrow mowing occurred as compared to plots that were interrow mowed. This suggests that competition from the alfalfa did have a slight reduction in corn plant stand, although the mechanisms of this stand reduction are not well understood.

Corn yield

Corn yield was low across all treatments with no treatment exceeding 45 bu/ac. The most dramatic difference in yield was with the addition of 25 lbs/ac of starter fertilizer which increased yield by 20.3 bu/ac over not applying starter fertilizer *(Figure 3).* Throughout the growing season, obvious differences in corn plant health and vigor were noted in plots containing starter fertilizer with corn taller and more advanced in growth stage. No difference in yield was observed with interrow mowing and nor with forage harvesting prior to planting.

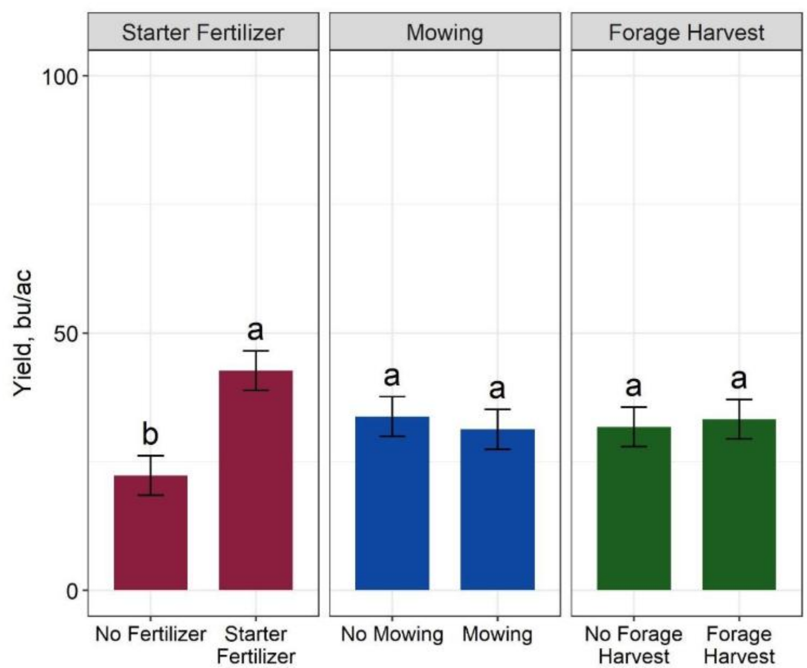

Figure 3. *Corn grain yield comparing the three studied factors of starter fertilizer, interrow mowing, and forage harvest. Means with letters that differ are statistically different within each factor (panel of the graph).*

Practical implications of these results

Growing conditions for this year were nearly ideal for corn growth with adequate and timely precipitation throughout the growing season and favorable temperatures for corn development. While in previous years, low corn yields had been attributed to competition between alfalfa and corn for moisture, that was not the primary source of low yields during this growing season. Instead, we observed nitrogen limitations as being a driving source in lowering yields. Historically, we have limited nitrogen applications in these systems, due in part to challenges in fertilizer placement in these reduced tillage systems, but also from hopes that these legume living mulches would supply some nitrogen throughout the growing season. However, this year we observed that nitrogen was a strongly yield limiting factor. While alfalfa should not be expected to contribute meaningful amounts of nitrogen while living, it was expected that interrow mowing would both limit competitive effects from the alfalfa and consistently provide nitrogen rich materials to the corn through trimming back the alfalfa. However, this year we did not see any difference in yield by interrow mowing. Part of this dramatic difference in yield where fertilizer was applied may be related to the heavy weed pressure and thinning stand of alfalfa which may have competed for nitrogen more than if a stronger stand of alfalfa had been present.

Similarly, our previous research has suggested that forage harvesting alfalfa before planting corn, while providing some added value to the living mulch, had negative effects on corn grain yield later in the season. It was hypothesized that this may be due to keeping alfalfa in a stage of rapid vegetative growth where it may be utilizing more resources in its vegetative stages rather than once it had reached its full growth potential. However, this year, we did not observe any difference in yield between forage harvesting and not forage harvesting the alfalfa biomass.

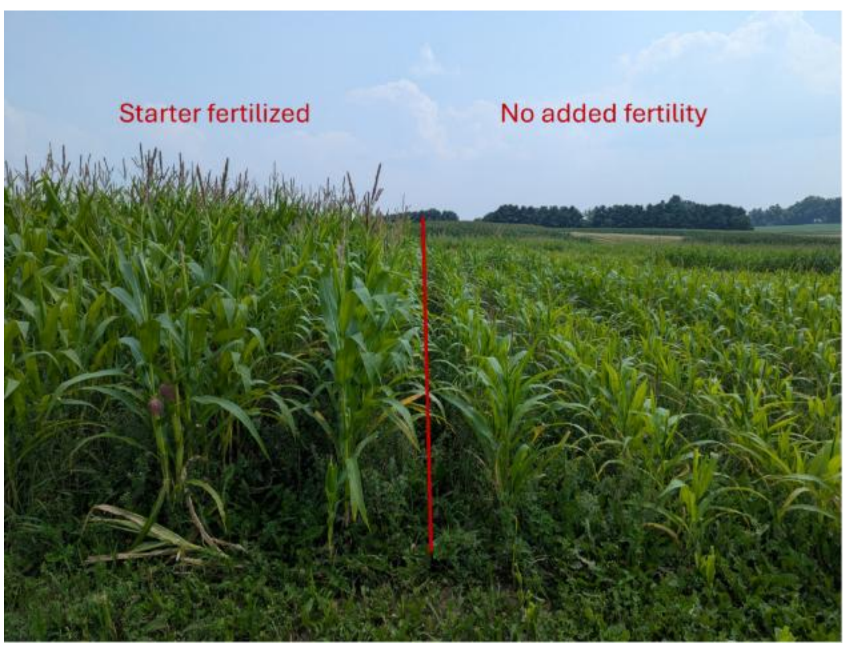

Figure 4. *Comparison of starter fertilized plots receiving 25 lbs N/ac vs plots that received no fertility in the alfalfa living mulch experiment, 2025.*

Field Management

Alfalfa in this study had been established in the fall of 2021 and was entering its fourth year. All field management activities are listed in *Table 2.* Strip tillage was performed twice, once in early May and again immediately before planting, in all plots that were not forage harvested using an Orthman 1tRIPr Within forage harvested systems, the initial strip tillage event was forgone to preserve alfalfa stand for harvest and was therefore only strip tilled following forage harvest and before planting corn. Corn (v. BR 24-82P) was seeded at 40,000 seeds/ac and select plots were fertilized with a 5-5-5 starter fertilizer product. Interrow mowing occurred three times, once at corn emergence as well as at the corn V3, and V5 growth stages.

Table 2. *Dates of field management activities for soybeans following an interseeded corn study to explore legacy effects of management on soybean production. This study was performed at the Arlington Agricultural Research Station with corn seeded into an existing alfalfa stand in 2025.*

Date	Field management activity	Plots impacted
5/9/2025	Strip tillage	All plots except those designated for forage harvest
5/29/2025	Forage harvest	Only plots designated for forage harvest
5/29/2025	Strip tillage	All plots
5/30/2025	Planting corn	All plots
6/11/2025	Interrow mowing	All plots designated for interrow mowing
6/20/2025	Interrow mowing	All plots designated for interrow mowing
6/30/2025	Interrow mowing	All plots designated for interrow mowing
11/14/2025	Harvest	All plots

Evaluating clover species and mowing management in an organic living mulch corn system

Main Takeaways

1) **Consistent early-season interrow mowing** reduced clover biomass, giving the corn a competitive advantage during its most sensitive early development stages.

2) **Yellow Blossom Sweet Clover** showed potential as a living mulch crop. When managed with interrow mowing, the YBS clover system trended towards higher corn yields compared to the red clover system, with an average of 37 more bushels per acre.

Introduction

Why are we doing this work?

Living mulch cover crops are often recognized for their benefits to long-term soil health, erosion prevention, and enhanced system biodiversity. However, competition between living mulches and cash crops often reduces crop yields. To limit potential competitive effects against cash crops, it is recommended to use living mulch species that are highly diverse in growth habit and lifecycle from the cash crop. Within corn systems, cool season legumes such as clover present promise as living mulches. While a variety of clover species have been utilized in living mulch systems, we have historically planted red clover as a living mulch crop due to its strong winterhardiness which allows for fall planting, allowing sufficient biomass accumulation to suppress weeds prior to planting corn. Yellow blossom sweet clover offers an alternative as a biennial clover species that, if planted in the fall prior to corn establishment, produces substantial spring biomass before completing its lifecycle and dying back during the corn growing season potentially limiting its competitive effect against corn. This stands in contrast to red clover which persists throughout the corn's lifecycle. To further reduce competition from living mulches and give the corn a competitive edge, interrow mowing (IRM) is a strategy that may be used within the growing season to manage clover biomass. How each of these clover species respond to IRM within a corn system remains unknown.

Objectives

n this experiment, we assessed the performance of yellow blossom sweet (YBS) clover species as compared to red clover in a living mulch corn system. Our objectives were to:

1) Evaluate the effectiveness of interrow mowing in managing early season clover competition
2) Explore how different clover species influence weed biomass and corn yields.

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Experimental design
This experiment was conducted at the Arlington Agricultural Research Station in Arlington, WI during the 2025 growing season. Half of the field was seeded with either red clover or YBS clover. We tested each cover crop with and without IRM management to determine the effects on weed biomass and corn yield. *(Figure 1)* Each treatment was individually replicated four times and organized in a randomized complete block design. The plots were designed to be 15 ft wide by 75 ft long.

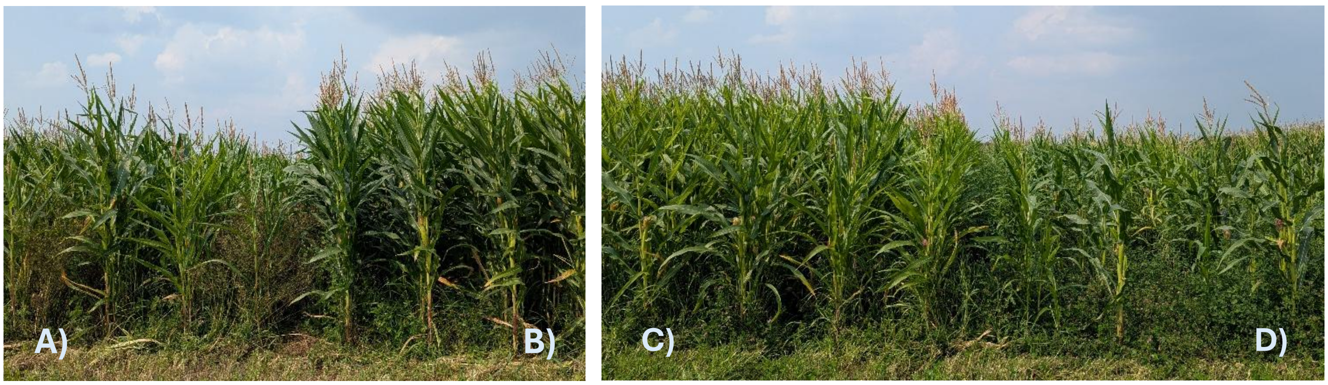

Figure1. *Four treatments implemented in the living mulch corn experiment at the Arlington Research Station in Arlington, WI during the 2025 growing season. A) Yellow blossom sweet clover living mulch with no interrow mowing management. B) Yellow blossom sweet clover living mulch managed with interrow mowing. C) Red clover living mulch managed with interrow mowing. D) Red clover living mulch with no interrow mowing management.*

Results

Clover Biomass

At corn planting, red clover produced less above-ground biomass compared to YBS clover *(Figure 2).* Red clover showed no statistically significant effect of mowing on late-season biomass reflecting its ability to regrow from crown buds, allowing it to rapidly replace biomass even after repeated IRM events. In contrast, YBS clover was killed by the mower after multiple IRM treatments as YBS clover grows from axillary buds and not from the crown of the plant like red clover. This resulted in no clover biomass when measured in early September. Interrow mowing events ceased at the corn V5 growth stage, just prior to corn canopy development. Observationally, YBS clover had been fully terminated by the mower by the final mowing event which opened up bare soil for weeds to emerge through; however, their ability to compete against corn was likely limited due to their late season emergence. Regardless, weed biomass was relatively high and trended higher in the YBS clover as compared to the red clover treatments *(Table 2)* although they were not deemed statistically different. Likewise, repeated interrow mowing events tended to reduce weed biomass as compared to no interrow mowing though was not different statistically.

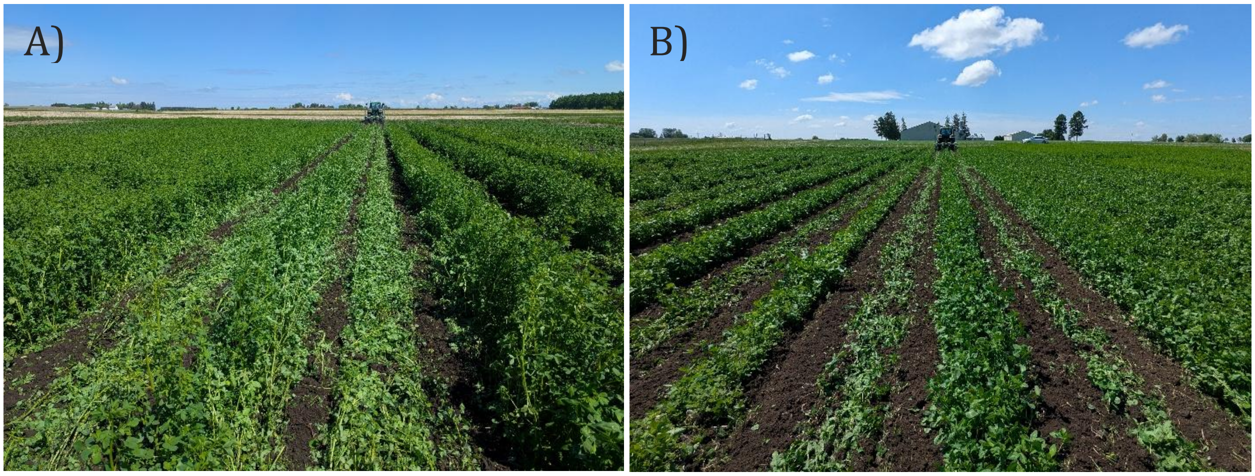

Figure 2. *Strip tilling prior to planting into A) the yellow blossom sweet clover and B) the red clover after one strip till pass. This experiment was conducted at the Arlington Agricultural Research Station in Arlington, WI, 2025.*

Table 2. *Statistical means for main effects of the different living mulch species and mowing management treatments. Clover and weed biomass were measured in early September. The Living Mulch Experiment was located at the Arlington Agricultural Research Station, Arlington, WI, in 2025. All means followed by a letter are statistically different at an alpha of 0.05 using Tukeys Post-hoc procedure.*

Effect	Clover biomass	Weed biomass
	------------------lbs/ac---------------	
Living Mulch (LM)		
Sweet Clover	**0 b**	2192
Red Clover	**501 a**	1219
Interrow Mowing		
Interrow Mowed	243	1238
No Mowing	258	2173

Clover Competition

To assess potential clover competition, we recorded the corn growth stages at five different intervals after planting across the four treatments, the two clovers species with and without IRM. *(Figure 3.)* YBS clover managed with IRM demonstrated numerically the most advanced growth stages throughout the growing beginning 30 days after planting and coinciding with the completion of interrow mowing events. Without interrow mowing, YBS clover trended towards less advanced growth stages at most measurement times but was only statistically lower at 60 days after planting. Similarly, red clover was more trended towards more advanced growth stages when interrow mowing was used and showed significantly greater growth stages at both 31 and 61 days after planting. These mowing events reduced clover biomass during critical stages of corn emergence and early development reducing competition for light and allowing corn to get a head start over the living mulch.

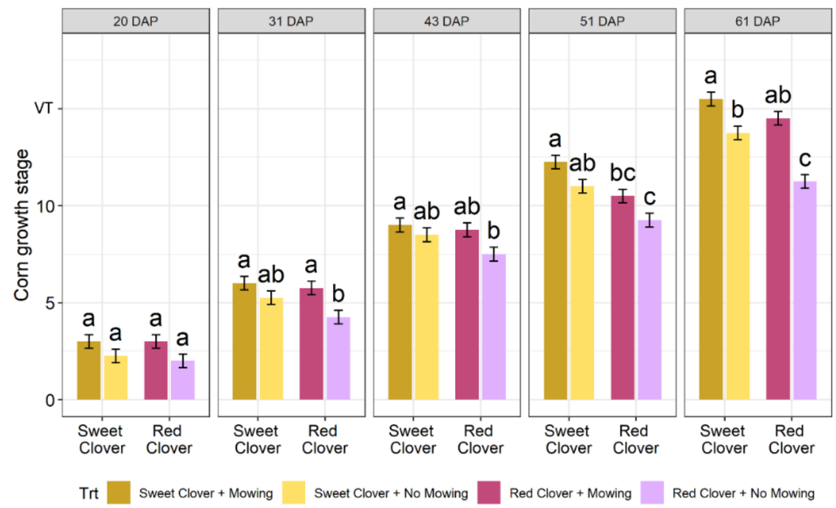

Figure 3. *Corn growth stages recorded on five different days across four treatments during the 2025 season. The treatments compared two living mulch species and their interactions with and without interrow mowing management. This experiment was conducted at the Arlington Agricultural Research Station in Arlington, WI.*

Corn plant stands

To assess whether IRM had any impact on corn plant stands, each treatment was measured at the V3 growth stage and at harvest. *(Figure 4.)* At the V3 growth stage there was relatively no difference between the corn plant stands of the four treatments. However, at harvest the red clover managed with no IRM was the only treatment to significantly affect the corn plant stands, with the final stand of this treatment being nearly half of what the red clover managed with IRM was. With IRM, both the YBS clover and red clover treatments trended towards having greater final stands than the treatments not managed with IRM. Together, these findings highlight red clover's potential to suppress corn stand when unmanaged, and the value of IRM in mitigating that pressure.

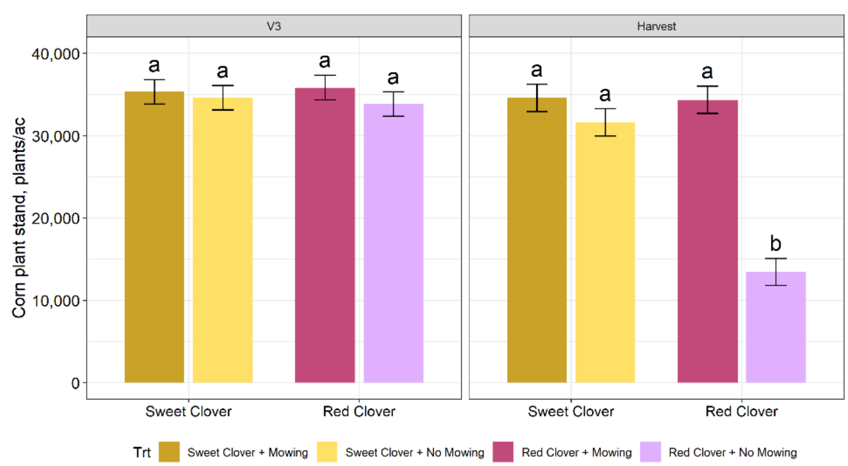

Figure 4. *Corn plant stands measured at the V3 growth stage and at harvest, comparing the stands of the yellow blossom sweet clover and red clover living mulch treatments with and without interrow mowing management. This experiment was located at the Arlington Agricultural Research Station in Arlington, WI.*

Corn Grain Yield by System

The red clover that was not managed with IRM had significantly lower grain yields than all other treatments, which was consistent with its reduced final plant stand. When comparing the grain yields across the remaining three systems there were no statistically significant results. (*Figure 5.)* With that said, the YBS clover system did trend towards higher yields on average.

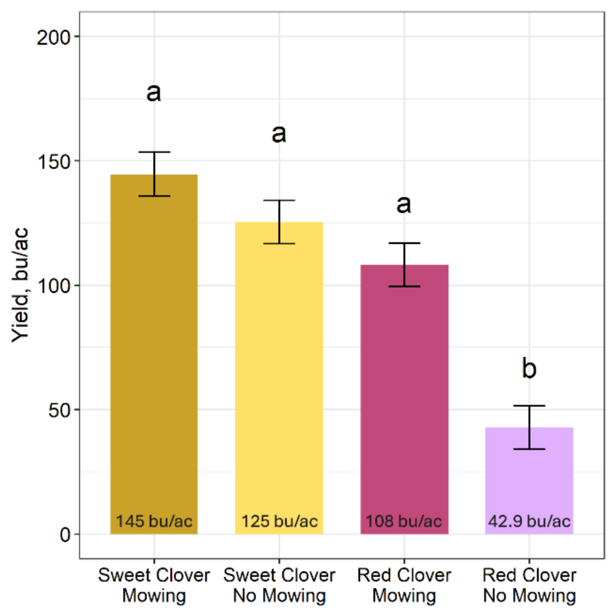

Figure 5. *Corn grain yields for the 2025 Living Mulch Experiment. Comparing the yields of the yellow blossom sweet clover and red clover, living mulch treatments with and without interrow mowing management. This experiment was located at the Arlington Agricultural Research Station in Arlington, WI.*

Crop Management

A complete schedule of our management practices can be found in *Table 1.* The living mulches were seeded in late August of 2024. Red clover (v. Freedom!) was seeded at 20 lbs PLS/ac, YBS clover (v. VNS) was seeded at 30 lbs PLS/ac, and oats (v. Reins) were seeded as a nurse crop in all treatments at 30 lbs PLS/ac. In May, composted poultry manure was applied at 2500 lbs/ac to target 100 lbs/ac of nitrogen. To prepare the seedbed, all plots were strip tilled twice before corn planting. Organic 82-day corn (v. BR 24-82P) was planted in late May at 40,000 seeds/ac with starter fertilizer applied in a 2x2 configuration to target 25 lbs/ac of nitrogen. Interrow mowing occurred at the V1, V3, and V5 corn growth stages to manage the clover biomass in designated plots.

Table 1. *Field management activities for our organic living mulch corn experiment with dates of occurrence spanning from September 2024 to November 2025 at the Arlington Agricultural Research Station in Arlington, WI.*

Field Management Activity	Date Managed
Clover Cover Crop Planting	Aug. 29th, 2024
Fertilization	May 7th, 2025
Strip Tillage	May 9th, 2025 May 29th, 2025
Corn Planting	May 29th, 2025
Inter-row Mowing	June 10th, 2025 June 20th, 2025 June 29th, 2025
Corn Harvest	Nov. 7th, 2025

Identifying factors influencing organic corn performance in living mulch

Main Takeaways

1. Specialty or indigenous corn varieties may be more viable for growing in living mulch systems.

2. When growing standard field corn varieties in a living mulch, selecting tall varieties with broader leaves, wider leaf angles, and overall denser canopies can help improve performance.

3. Symptoms of competition stress (shorter plants, lower SPAD values) appear early in the season and SPAD values decrease as living mulch biomass increases, indicating that competition management is particularly crucial in the early season.

Introduction

Living mulches offer management and ecosystem benefits…

Organic farmers often rely on tillage to manage weeds, but frequent soil disturbance has been shown to negatively impact soil health. This understanding has sparked interest in minimal-tillage organic practices such as living mulch. Similar to both intercropping and cover cropping, growing a living mulch involves allowing a cover crop to continue growing between the cash crop rows. This practice offers all of the same benefits as cover crops, but for a greater duration of the year: it keeps the soil covered, minimizing disturbance, erosion, and water loss, it improves microbial activity and soil structure, and contributes organic matter to the soil. Legume living mulches also contribute additional nitrogen. Beyond these ecosystem services, living mulch can operate as a weed management strategy by outcompeting and suppressing weeds.

…but the yield gap remains the largest barrier to adoption.

Despite all of these benefits, living mulch systems consistently see lower yields than standard tilled organic systems because of the competition between the living mulch and the cash crop, making the system economically unfeasible. Prior research has identified that combining strip tilling and regular inter-row mowing makes a significant difference in beginning to bridge this yield gap. To make further progress in this effort, this research investigates how corn varieties, their physical attributes, and planting densities influence corn performance in a living mulch system.

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Results

Corn Grain Yield

Both the Specialty and Field Corn experiments saw better yields in 2024 than in 2025, with smaller yield gaps in the Specialty varieties across both years and a nearly negligible yield gap between the living mulch and full tillage plots for the Specialty varieties in 2024 *(Figure 1).* This suggests that specialty varieties, particularly the Caribbean Flint variety, may be better adapted to high-competition environments and more suitable for growing in a living mulch.

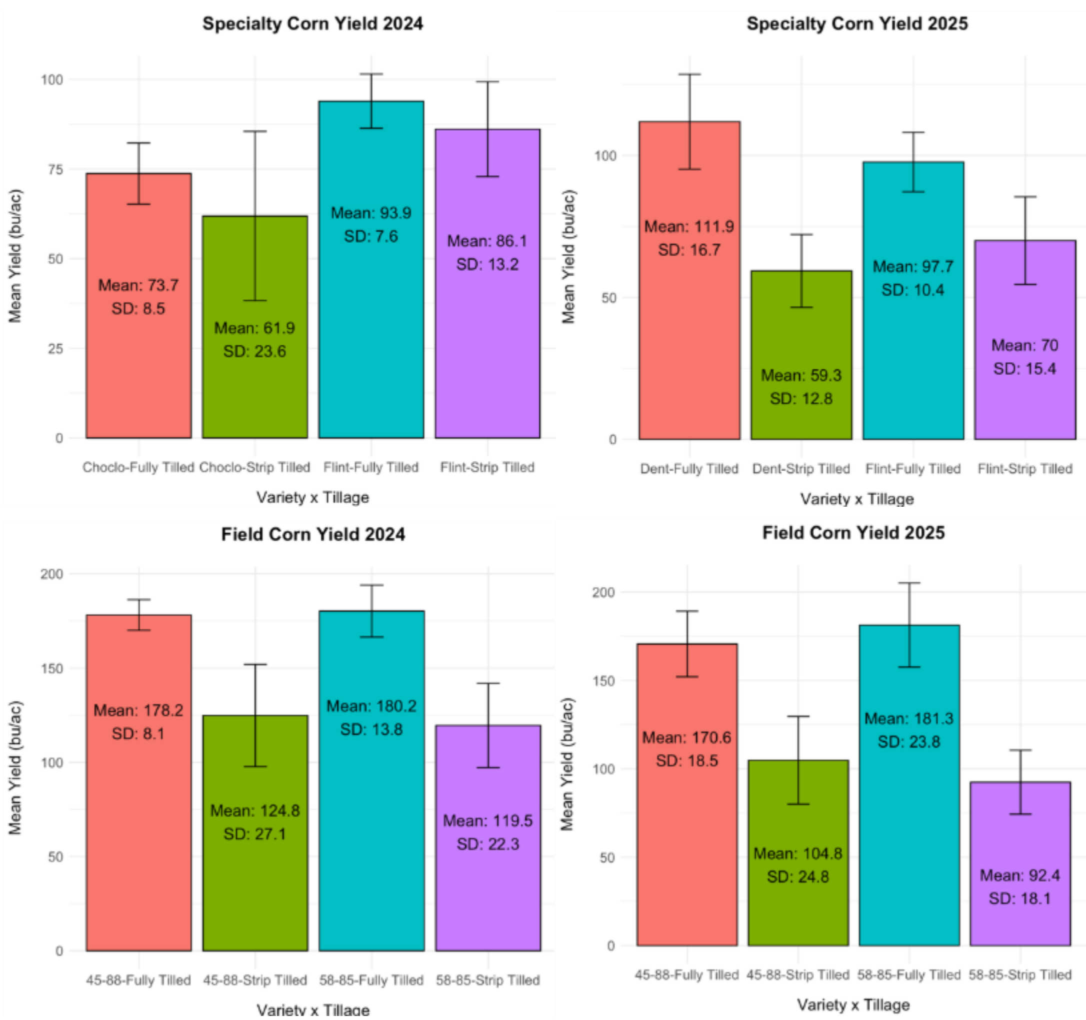

Figure 1. *Corn grain yield in the Specialty Corn and Field Corn experiments across the 2024 and 2025 growing years, broken out by variety and tillage treatment.*

Corn Physical Traits

In both 2024 and 2025 and across both commercial field corn varieties, positive correlations were seen between yield and all measured traits (leaf angle, leaf width, and plant height) in the strip tilled living mulch plots, while no significant trends were seen in the fully tilled control plots *(Figure 2).* Statistical analysis revealed clover biomass, leaf angle, and plant height to be the most influential variables in a linear mixed model of the yield in 2024 *(Figure 3).* This indicates that in a living mulch system, greater values for these traits influence the competitiveness and subsequent performance of field corn varieties. No similar trends were seen between yield and any measured traits in the Specialty varieties experiment.

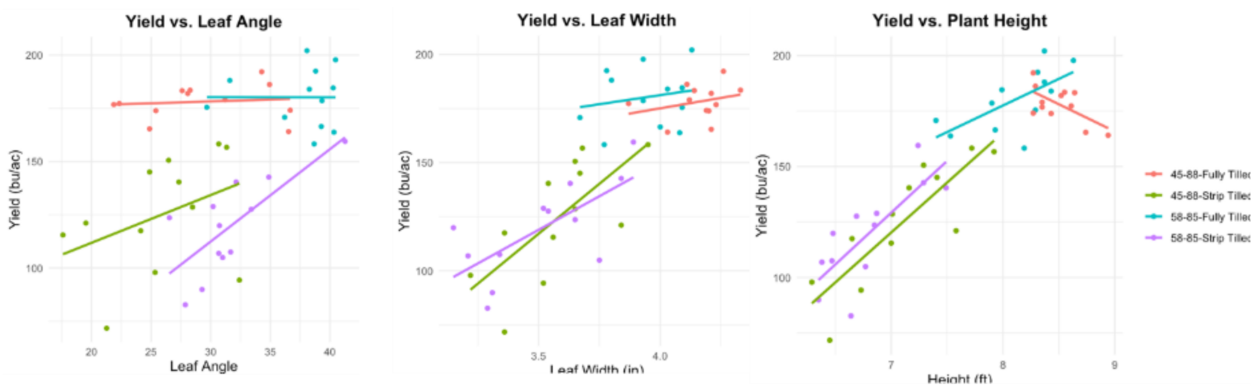

Figure 2. *Relationships between yield and physical traits of corn plants (leaf angle, leaf width, and plant height) Field Corn experiment during the 2024 growing season.*

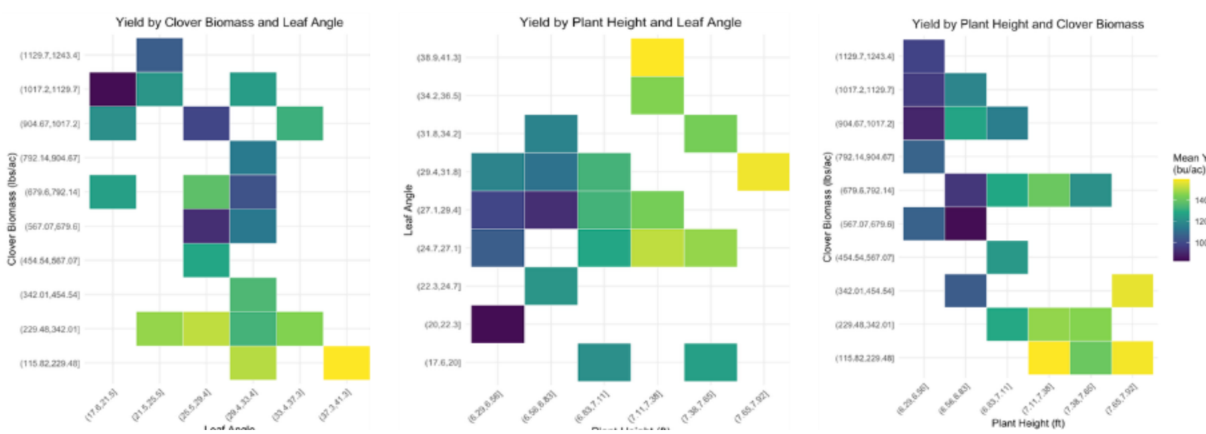

Figure 3. *Relationships between yield and leaf angle, clover biomass, and plant height of corn plants in the Field Corn experiment during the 2024 growing season.*

Clover Biomass

As red clover biomass increased in the 2024 Field Corn experiment varieties, SPAD values at the V5/V6 growth stage decreased *(Figure 4).* This trend was also reflected in grain yield, indicating that the corn is not picking up as much nitrogen in the strip tilled living mulch plots. This may be due to nitrogen consumption by the clover, which will put less energy into fixing atmospheric nitrogen if there are easy and abundant nitrogen sources in the soil. These results suggest that early-season competition management is crucial for success at harvest.

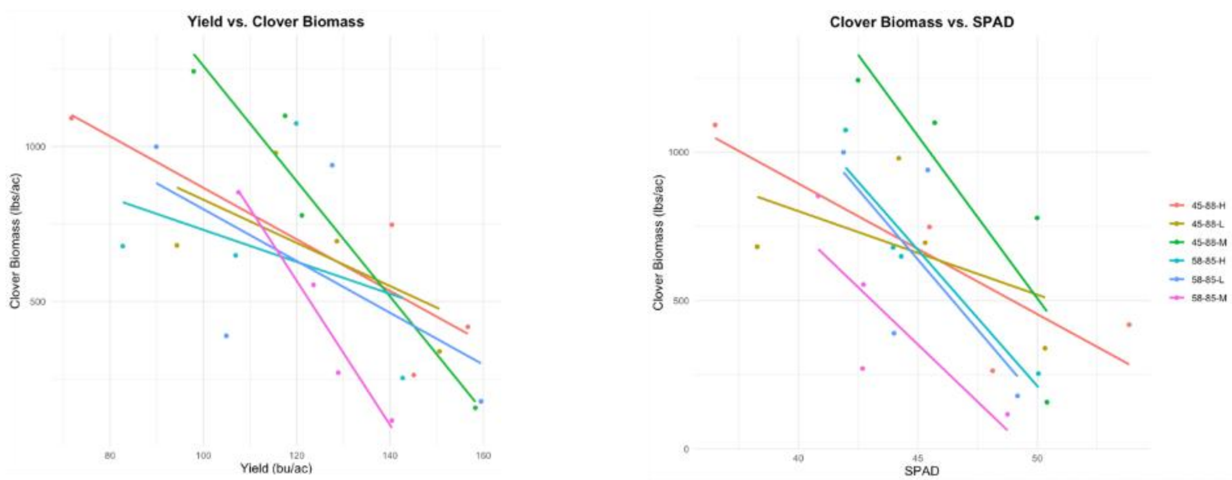

Figure 4. *Relationships between yield, clover biomass, and V5/V6 growth stage SPAD values of corn plants in the strip tilled living mulch plots of the Field Corn experiment during the 2024 growing season.*

Experimental Management

Experimental Design

This research was conducted at the Arlington Agricultural Research Station in Arlington, WI during 2024 and 2025. Two independent experiments, one comparing two commercial field corn varieties and another comparing two specialty varieties, examined how physical plant traits and planting density influenced corn performance in a red clover living mulch. The physical traits measured included SPAD, leaf width, leaf angle, plant height, and canopy density. Each treatment combination was replicated four times in a split-split plot design with factorial randomized subplots that spanned 15 x 45 feet. *(Figure 5).*

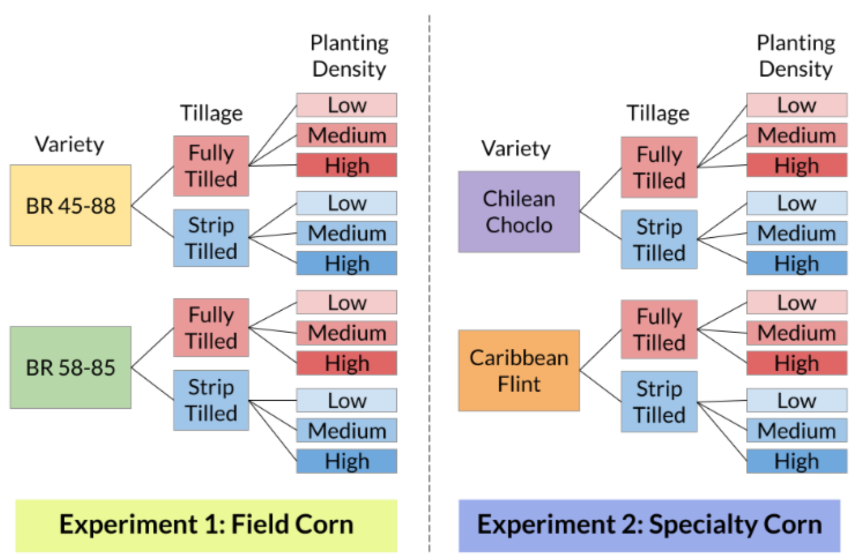

Figure 5. *Graphical representation of experimental treatments in the field corn and specialty corn experiments at the Arlington Agricultural Research Station, Arlington, WI, 2024-2025.*

Crop Management

A red clover cover crop (chosen for its ability to provide additional nitrogen) was seeded in fall 2023 and 2024 at 13.6 lbs/ac and overwintered. All full-tillage subplots were tilled using a field cultivator and all living mulch subplots were strip-tilled to terminate the in-row clover. Composted poultry manure was broadcasted in mid-May at a rate of 3500 lbs/ac (175 lbs/ac of N) in the Field Corn experiment and 1500 lbs/ac (75 lbs/ac of N) in the Specialty Corn experiment. Corn was planted on June 12th in 2024 and May 29th in 2025. Starter fertilizer (Probooster 10-0-0) was applied at planting at a rate of 300 lbs/ac (30 lbs/ac of N) across all plots. The field corn varieties (Blue River 58-85 and Blue River 45-88P) were seeded at scaling rates of 30, 35, and 40,000 seeds/ac. The specialty varieties (Caribbean Flint, Chilean Choclo in 2024, and Garish's Dent in 2025) were seeded at 25, 30, and 35,000 seeds/ac. All plots were tine weeded after planting and emergence, with between-row tines tied up for the strip tilled plots. The red clover living mulch was inter-row mowed three times, first at emergence and then at 10-day intervals.

Table 1. *Timeline of data collection activities for the field corn and specialty corn experiments at the Arlington Agricultural Research Station, Arlington, WI, 2024-2025.*

Data Collection Activity	Collection Timeline
Clover and Weed Biomass	Collected before and after tillage
SPAD Measurements	Taken at the V5/V6 growth stage and at corn tasseling
Leaf Area Index	Collected two weeks after corn pollination
Leaf Angle	Collected two weeks after corn pollination
Leaf Width	Collected two weeks after corn pollination
Plant Height	Collected two weeks after corn pollination
Lodging Rate (*)	Collected two weeks after corn pollination
Clover and Weed Biomass	Collected two weeks after corn pollination
Corn Grain Yield	Taken at harvest

(*) Taken only during the 2024 growing season

Using warm season grasses in a grazing rotation

Main Takeaways

1. **Biomass** on field was significantly higher in warm season pastures than cool season ones. Though, cool season pastures had shorter recovery times and could be grazed more often. Warm season pastures were successfully grazed throughout the "summer slump" period without impacting field health in the following season.

2. **Forage quality** was not significantly different across warm and cool season treatments, despite the fact that cool season forages had significantly better sub-metrics. Warm season forages did not have enough protein to be recommended for lactating cows, but could be used well for heifers, and fiber was high enough to impact DMI in all forages except cool season pasture.

Figure 1: Cattle Shed in Cool Season Pasture 207 on a foggy day in May.

Research Implications

Warm season forages likely won't replace cool season grasses any time soon, but they show evidence of being a suitable quality to include as feed to either supplement pastures during the summer slump and decrease the cost of inputs by expanding the recovery period on your cool season pastures. Or they can be used for dry cows such as heifers and improve ecosystem services while decreasing the cost of feeding the least profitable members of a herd.

Introduction

Why are we doing this work?

Whether for increased environmental benefits, adding resilience to the farm, or supplementing pasture production during the "summer slump", there has been strong interest amongst dairy grazers for information about warm season grasses. These grasses are C4-grasses (such as corn-maize) which have their highest rates of photosynthesis during warm periods of the year, such as summer. While warm season species are widely used and discussed in the southern united states, the Upper Midwest has been dominated by introduced European cool season species, prioritizing the longer cool periods at the beginning and end of the grazing season. This research seeks to address these gaps by comparing the performance of both warm and cold season grasses as productive forage. Measuring standing biomass on the field, relative forage quality (RFQ) and important sub-metrics such as aNDFom and crude protein.

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Results

Biomass

Biomass production showed three groupings across the treatment types. The diverse planting prairies had the highest amount of recorded biomass, and Cool season (CS) pastures had the lowest. Strictly palatable biomass production in the two treatment groups (HDP, LDP) was much closer to cool season production rates. It is also worth noting that while CS pastures had significantly lower standing biomass, they were able to maintain this average while being grazed 3-4 times each season. Whereas the warm season pastures were each grazed only once per season.

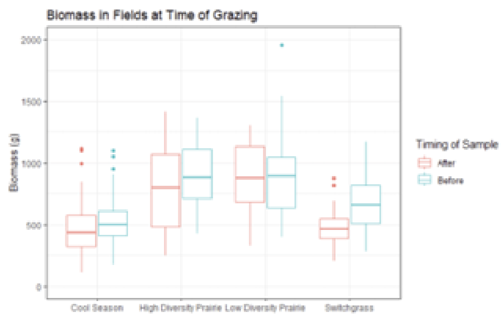

Figure 4: Distribution of biomass in grams per meter[2] across treatments before and after grazing events

Relative Forage Quality

There were few significant differences between the cumulative sample forage quality before grazing. This is likely due to the large variation seen in the CS treatment group. Notably, the only statistically significant difference came from comparisons between palatability rather than directly between treatments. The highest average RFQ was recorded in the LDP unpalatable group, challenging the expectation that palatable forages were going to be the most palatable. The lowest mean RFQ was found in the unpalatable switchgrass.

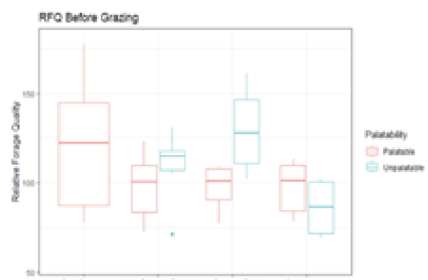

Figure 5: Distribution of RFQ values by treatment before grazing.

Grazing seemed to impact the quality of the warm season prairies more than the CS plots. For most of the treatments, there was a general decrease in the mean RFQ of the samples. There were few changes in the relationships across treatment types, however. Unpalatable SG samples remained at the lowest mean RFQ and were again significantly different from the highest mean value.

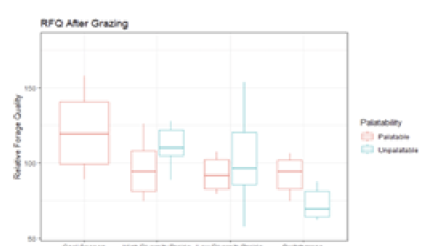

Figure 6: Distribution of RFQ values by treatment after grazing

aNDFom

aNDFom continued the pattern of "unpalatable" forages showing better metrics for forage quality than their "palatable" counterparts. The lowest mean aNDFom was found in the CS treatment. The only treatment found to be different from the CS value however was HDP-palatable. Broadly, the warm season forages were a statistical grouping, as none were statistically different from each other, except for the unpalatable forages in HDP and LDP treatments.

Post-grazing samples maintained the pattern seen above, with similar significant groupings. The largest change was a general increase in the percentage of aNDFom in samples across the board.

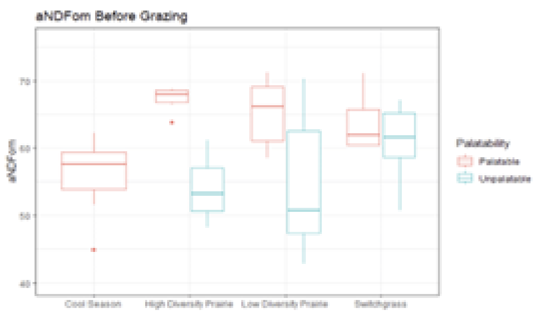

Figure 7: Distribution of aNDFom values across treatments before grazing

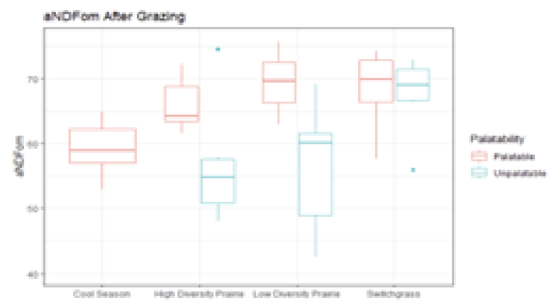

Figure 8: Distribution of aNDFom values across treatments after grazing

Crude Protein

Crude protein percentages saw the largest difference between the cool season and warm season forages. For both pre-grazing and post-grazing samples, CS samples were significantly higher than all of the warm season forages. None of the warm season forages were significantly different from each other, establishing a clear difference between the two forage types.

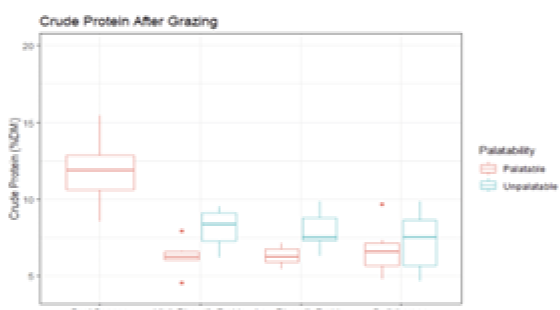

Figure 10: Distribution of crude protein values across treatments after grazing

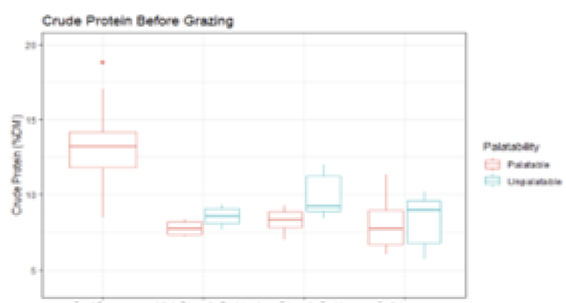

Figure 9: Distribution of crude protein values across treatments before grazing

Experimental Management

Experimental Objectives

In this experiment, we wanted to see how effective a variety of native and warm season grasses could be in a rotational grazing regime. We used a small herd (6 heifers) and rotated them through different treatment pastures, sampling the biomass and forage quality before and after grazing to better understand the quantity and quality of forages produced by each field, as well as the voluntary intake of the herd in each field.

Experimental Design

This study was conducted across two grazing seasons at the pastures on the Wisconsin Integrated Cropping Systems Trial (WICST) on the Arlington agricultural research station. The results included here represent the combined data from both years in order to mitigate biases from a given annual weather pattern. The plots used in this trial are made up of four separate forage composition types. 1) Cool Season grasses (CS), 2) Switchgrass prairies (SG) ,3) Low Diversity Prairies (LDP), and 4) High Density Prairie (HDP). CS plots had an area of 155 m in length and 18m in width. These plots were broken into subplots for daily grazing, consisting of fourteen different 11m by 18m plots in the early portion of the season, and seven 22m by 18m plots in the latter half of the season. The grazing areas of the warm season prairie plots were composed of 14 m width by 75 m in length and were grazed in their entirety for a 3-day (~72 hour) duration.

Figure 2. *Warm season plot map #1, courtesy of WICST (2023)*

-N / +N	503 NS2 LDP	Grazing
+N / -N	502 NS3 HDP	Grazing
-N / +N	501 NS1 SG	Grazing

Figure 3. *Warm Season plot map #2, Courtesy of WICST (2023)*

+N / -N	509 NS3 HDP	Grazing
-N / +N	508 NS1 SG	Grazing
-N / +N	507 NS2 LDP	Grazing
+N / -N	506 NS3 HDP	Grazing
-N / +N	505 NS2 LDP	Grazing
-N / +N	504 NS1 SG	Grazing

Figure 4: A 1m2 sampling plot in a cool season pasture prior to grazing. July 8th, 2023.

Forage samples were collected to determine the biomass yield and forage quality rates of each treatment. Each field was sampled twice, with one sample being collected prior to a grazing event, here defined as within six days of cattle being added to the pasture. A second round of samples was then collected after a grazing event, here defined as within 2 days of cattle being removed from a pasture. Individual samples consisted of $1m^2$ areas of biomass being collected to a 1.5-inch aboveground remainder. This remainder was left to minimize bare ground plots that might impact future grazing events and influence later data collection.

Samples were then dried in a drying room at 45-50^{0}C for one week before being weighed for biomass. The collected forage samples were then kept in the WICST drying room at a temperature of 50^{0}C for a week's time (7 days) before being weighed for biomass samples. One randomly selected sample from each pasture was chosen via random number generator (integers 1-6) to be set aside after biomass measuring for later forage quality testing. Samples earmarked for quality testing were kept in the WICST freezer for long term storage. Prior to forage testing, samples were sorted and rebagged into palatable and unpalatable forages. Palatable forage being considered grasses, clovers, and sedges. Unpalatable forages were amaranths, forbs, and other woody species that cattle consistently avoid in grazing. Sorted bags were then redried for a minimum of 72 hours to reduce the impact of freezing, and ground to 5mm particle size to provide a uniform sample for testing.

Field Management

This research was conducted on the WICST grazing pastures, and as such follows their management protocol. Designed to test a variety of practices on the same land, portions of the fields were mowed and baled to test hay production *(Table 1)* while prairies were burned in early spring each year. Due to changes in plant species demographics, cool season pastures were drilled and reseeded with persistent red clover in the late summer season of 2024. Cool season pastures were also mowed in the late season of 2024 to remove dead grass prior to over-wintering. Minor herbicide applications were performed to keep broadleaf weed encroachment reduced around the cattle sheds on research plots in order to maintain ease of use while transferring herds.

Table 1: *Management practices on the WICST grazed pastures.*

Management Activity	Cool Season Pastures (plots 207,302,405)	Warm Season Prairies (plots 501-509)
Mow and Hay conditioning	2024-05-29 (405) 2024-08-22 (207) 2024-09-09 (302) 2024-09-16 (405) 2025-10-03 (mowed to 6”)	
Burning		2024-04-10, 2025-04-12
Fertilizer application	2024-07-17 (130lbs/acre 46-0-0) 2025-04-07 (92.57lbs/acre 0-0-62) 2025-05-28 (130lbs/acre 46-0-0) 2025-11-17 (2.5 Ton/acre Lime)	
Seeding	2024-08-28 (207;8lbs/ac Persist red Clover) 2024-09-10 (302;8lbs/ac Persist red Clover) 2024-09-16 (405; 8lbs/ac Persist red Clover)	
Herbicide application	2025-10-06 (2pints/acre 2,4,D around sheds)	2025-06-04 (502,504,508; 2pints/ac Amine-4 [2,4,D] around sheds)