Okay? Well, I think that we should get started, since it is at the hour, and I'm glad to see a number of people here with us this morning.

My name is Andrea Basche. I'm an associate faculty, professor research and teaching role at the University of Nebraska in the Agronomy department, and I've been leading with a great team of folks a collaborative agreement respective to looking at cover crops across Nebraska and Vesh Thapa, who presented on our 1st Webinar series is going to share with you today some of the work we've been doing on this project and others

specific to this question of how much cover crop biomass should we really expect in Nebraska? Again, building around our series on what are some of the common challenges? Because a common issue is, just.

do I have enough time to plant

and terminate this cover crop between my corn and soybean rotation really to get enough growth. So, what's realistic to expect for Nebraska. That's going to be our topic today. So, with that, I want to turn it over to Vesh and to Nathan for the formal presentation and discussion

Nathan Mueller (NRCS)

Yeah, thanks, Andrea. Just a few logistics for the NRCS folks again, Nathan Mueller. State soil health specialist for NRCS for those of you joining us from UNL as a part of this

Really good collaboration. Thank you. For the NRCS folks. We will be putting together a feedback form through Microsoft forms that we'll send out to gather your feedback on this Webinar series. It's been fantastic, but we want to hear your thoughts and honest feedback, and if, whether it's something that we should keep pursuing and maybe changes we might make in the future. So thanks in advance for your feedback and look for that, probably coming out sometime in February. So, thanks, I'll turn it over to Vesh

Vesh Thapa

Yeah, thank you, Nathan

Good morning, everyone! Welcome to Session 4. We're excited about today's dialogue between NRCS and UNL Extension educators, To get started, we'd like to launch a quick poll—just like in our previous sessions—to see where everyone is joining us from, This helps us group you by region for the breakout rooms, so we can strengthen connections between UNL Extension and NRCS

Grace or Bridget, please launch the poll now. Once we have enough responses, share the results and create breakout rooms accordingly, The plan for this morning is that I'll present for about 40-45 minutes, then we'll move into our breakout discussions, We have facilitators assigned to help keep the conversation moving and take notes, Thank you for your participation—let's see how many folks we have from each region

I see 20 people responded to the poll, I think you can end the poll Now, Okay? So, I'll go ahead

We mentioned this during our previous calls, but I'd like to emphasize it again, I really appreciate the number of Extension educators who have committed to join us, If you're within our service area and looking to locate Extension educators in your region, the epd.unl.edu website is an excellent resource, We offer a wide range of Extension programs covering many topics—not just crops, water, and livestock, There are also programs in areas such as rural development and youth programming, You may already be aware of these options, but you can explore the full range of categories by using our search feature

We built this webinar series around three key topics: how cover crops affect yield, their water use, and their return on investment, I'd like to offer a quick refresher from our past three webinars. In our first session on October 1, I presented some of the specific processes through which cover crops influence cash-crop yields, Research across farms, small-plot experiments, and farmer surveys often shows that cover crops have a generally neutral effect on yields overall, Legumes or mixed cover crops before corn can boost yields, while late-terminated grasses sometimes reduce them in dry years, Although studied less, wheat and soybean exhibit similar patterns; cereal rye before soybean tends to be less detrimental than it is before corn, Once the management learning curve is overcome, negative yield effects can be minimized and, in many cases, avoided

I'm not going to go into detail on this slide, It's just a brief summary of some of the research reports we discussed, I understand that in your portal these papers we shared are organized, so you should have them as a resource, All of these experiments took place in Nebraska, examining cover crops and their impacts on yield. That was the focus in October

In November, we focused on how cover crops affect water, This concern commonly comes up because people worry that cover crops might use too much water before the cash crop season, Cover crops do affect the entire water cycle, from reducing evaporation and increasing infiltration to potentially impacting soil water storage, These effects can be very positive—research shows cover crops can reduce runoff and improve soil infiltration and water storage capacity, However, in drier years, we sometimes see cash crop yield reductions following a cover crop, On the other hand, in wetter springs or seasons, cover crops can be beneficial by taking up excess moisture, Effective management—especially in timing and termination—can help ensure that the benefits outweigh any potential drawbacks

And again, here is a brief summary of the research we covered in November's webinar, We've organized these resources for you, but I won't go through them in detail, This recap simply highlights the key points about the positive—and sometimes more complex—effects that cover crops can have on water

In December, we focused on cover crop return on investment, This recap simply highlights the key points, Cover crop costs and returns can vary based on different assumptions and scenarios, A partial budget approach includes costs like seed, labor, and equipment, along with possible revenues like higher yields or grazing, Many farmers report positive returns after a few years, Tools like the UNL crop budget platform, the ABC Calculator, Iowa State's net returns calculator, and reports from the Soil Health Institute, SARE, and American Farmland Trust provide helpful guidance

Coming back to our today's session, so I'll be talking on how much cover crop biomass can we expect in Nebraska? This is the outline of my presentation. I'll be talking about introductions and why biomass really matters, and I will be talking on the factors influencing cover crop biomass productions and provide some research and evidence and give some of the take home messages and then we will move into the breakout room discussion

I'll be talking about what biomass is and why that matters. Let me begin with the definition? What is Biomass? Biomass yield refers to the total amount of plant material produced (e.g., leaves, stems, roots) per unit area over a given period, Aboveground means shoot and below ground means roots, I always emphasize and give equal importance to belowground productivity as aboveground because It has been estimated that cover crops provide 50-75% of their fixed carbon to soil through roots, and Carbon derived from roots builds soil organic matter 5-30 times faster than above-ground biomass

Cover crops offer multiple ecosystem service benefits such as improving soil properties and processes. They help to suppress weeds, they facilitate crop pollinators, and they provide habitat for beneficial, predatory insects. They can also serve as a forest source for livestock, However, the magnitude of ecosystem service benefits provided by cover crop is closely linked to their biomass production

A meta-analysis in the U.S. Midwest reported that a minimum biomass of 5.0 Mg ha^{-1} is required to reduce weed biomass by up to 75%, Similarly, this laboratory study indicated that at least 5.0 Mg ha^{-1} of cover crop residue is necessary to maintain soil organic carbon in hot, dry agroecosystems, This field study from Central Great Plains reported that approximately 7 to 8 Mg residue $ha^{-1}yr^{-1}$ would be needed to maintain soil organic carbon stocks under limited irrigation, This study showed that small grain cereals can yield 2.1 to 6.0 Mg ha^{-1} biomass and serve as high-quality forage source for livestock, Similarly, this study from Europe suggested 1 Mg ha^{-1} biomass threshold is needed for soil nitrate reduction

These are some of the few examples I would like to show how the ecosystem service benefits we get from cover crop is linked to their biomass

So, moving ahead, I'll be talking about some of the factors that influence biomass production

Biomass production depends on various factors, including species selection, climate, soil characteristics, and management practices, Species selection is important because adaptation of species determines their productivity, and productivity can vary within the same species due to differences in plant hardiness or local landscape features

Biomass accrual is highly dependent on weather, specifically precipitation and temperature, where a warm-wet growing season typically produce more biomass than a cool-dry season

Soil properties, particularly organic matter content, nutrient availability, and water retention capacity, significantly affect biomass production. For instance, soils rich in organic matter enhance nutrient cycling and storage, improve soil structure, and increase water retention, thus promoting higher biomass yields

With regards to management factors, planting and termination dates play a vital role in biomass production because these dates determine the length of the growing period and the environmental conditions to which cover crops are exposed, For example, early planting and late termination typically allow for higher growing degree days accumulation. Also, early fall planting improves survival chances during winter, thus leading to greater biomass yield, Conversely, late planting and early termination result in reduced yield due to shorter growing periods and sub-optimal growing conditions. It has been reported that planting beyond October 05 leaves insufficient heat units for extensive cover crop growth and development

Species selection is a critical factor because it influences the adaptability and productivity. How? It is because different species possess inherent traits that determine their competitive ability and complementarity under specific environmental conditions, For instance, grasses are generally more adaptive to adverse environments, their dense fibrous root systems excel at resource acquisition such as water, nutrients, and sunlight, which supports robust growth and biomass production, Grasses not only produce higher biomass but also exhibit higher CN ratios (> 25:1). This highlights their utility for increasing soil carbon inputs. Because of higher CN ratio their residue decompose more slowly contributing to organic matter buildup

Conversely, legumes with their Nitrogen fixing ability perform well in Nitrogen deficient soils, while brassicas offer benefits such as soil aeration due to their deep rooting. But legumes and brassicas both are more sensitive to climatic stressors than grasses

When included in mixtures, the functional differences among species enhance resource-use efficiency, as they fill distinct ecological niches and collectively boost overall productivity

In this slide I am going to focus why Range must be considered over mean when estimating biomass?

Mean, we all know, it is the average biomass yield. While it is useful, it doesn't capture the full story of how our cover crops are performing, While Range refers to the variability in biomass yield, it includes both the minimum and maximum yields observed, Then why is range important over mean? Because different regions vary in soil types, water availability, or sunlight exposure, and thus lead to different yields, And focusing only on the mean might overlook variability in biomass yield

So, understanding the range helps us know the potential low-yield areas and make informed decisions to improve consistency, For example, a wider range means more variability, which could indicate a need for better management practices or adjustments in inputs

This study including about 6000 observations across 208 site-years in the eastern half of the US found cereal rye biomass ranging from 265 to more than 6,000 kg Per hectare

Similarly, this is a review of about 400 papers, and it also indicated the range of biomass production. You can see from 410 to even more than 6,000 kg. Per hectare. So, if we have only focused on mean, you can see like mean is about 3,000 kg. Per hectare. But if you see the range, you can see the lowest potential areas with even 410 kg per hectare

So now I would like to move ahead in the context of Nebraska

Nebraska's annual precipitation varies significantly from west to east, ranging from 13 to 35 inches. This east-west precipitation gradients create distinct climatic conditions and soil environments, For example, eastern regions receives higher precipitation and have lower evaporative potential. This tends to have soils with higher organic matter content and better water availability, supporting greater biomass production, In contrast, western regions receives lower precipitation and have higher evaporative potential. Soils are also low in organic matter content and have reduce water availability, limiting biomass yield, So, this differences in regional climatic conditions and soil type emphasize the necessity for region-specific management strategies to optimize biomass production

And when it comes to variability in annual biomass production, it is often tied to year-to-year differences in temperature and precipitation, For example, above-average temperatures and precipitation levels during cover crop growing period (15 ºC and >225 mm; September to April) are generally associated with higher yields, whereas below-average conditions tend to reduce yield, Since year-to-year variations in these weather factors are common, we cannot expect a substantial amount of biomass every year

In Nebraska, there is a high level of seasonal and interannual variability in climate, with recurring periods of intense drought and frequent strong winds, Therefore, understanding the variability in biomass production during the winter growing period, is crucial for setting realistic expectations based on the diverse conditions that can occur during winter

I'm going to talk about some of the research evidence from Nebraska that shows the variability in biomass production

We reviewed the biomass yield of four species (rye, triticale, wheat, and canola) across diverse locations and planting regimes in Nebraska. We wanted to generate a spectrum of biomass estimates for these species of interest, Our goal was to investigate seasonal variation in biomass production across Nebraska, particularly in response to harsh winter conditions. We also wanted to assess whether these seasonal differences result in variable outcomes, without any season being consistently exceptional or unfavorable

Biomass measurements for these species were taken from various sampling times, ranging from early fall to late spring of the following year, and accounted for different precipitation gradients and soil types, Majority of the studies in this review were from eastern Nebraska, with fewer studies from the central and western parts of the state

This review of 18 studies revealed that among the studied species, rye was the most widely grown species, and there was significant variability in biomass production for all four species, for the rye, we got the biomass range from 190 to more than 6,000 kg. Per hectare, so triticale, 750 to about 7,000 kg. Per hectare, and so forth for canola and wheat, So you can see if we would have focused only in the mean, we would just report about 2,000 kg. Per hectare. But when we are considering the range, we found the range was from 100 to more than 7,000 kg. Per hectare

We further classified the studies based on precipitation zones, We found majority of studies were conducted in semi-humid regions, with precip. of 700 – 850 mm, followed by transition zones (550 – 700 mm precip.), and semiarid regions (<550 mm precip.), Depending on the species, in semi-humid regions, biomass production ranged from 100 to 7160 kg ha^{-1}, in transition zones from 270 to 4340 kg ha^{-1}, and in semiarid regions from 110 to 4220 kg ha^{-1}, All three grass species (rye, triticale, and wheat) in semi-humid areas showed average biomass production of ≥ 1958 kg ha^{-1}

you can see the range of biomass production for each species in different precipitation zones

In this field study, four species of interest – Gore winter wheat, Elbon rye, triticale, and Trophy canola — were grown and monitored at the "Spidercam" experiment at ENREEC near mead in eastern Nebraska, This unique phenotyping site is equipped with an automated cable-suspended carrier system that accommodates multiple cameras and various types of sensors, On-site sensors and cameras capture plot-scale ground cover and canopy height data at a sub-weekly time intervals

Cover crops were drilled in September of both 2021 and 2022, and terminated in May of the following year, The APSIM model was tested for its ability to predict biomass production using data from this unique phenotyping experiment, We also wanted to compare how well the model-predicted results align with previously published data for the state, which is the review I talked in previous slide

Figures on the right show that the seasonal weather conditions made each year's cover crop growth uncertain, wheat and rye survived in both winters while triticale and canola did survive in only one winter, Over the two years, significant differences were observed in biomass yield

Wheat and rye in the first growing season showed significantly higher biomass yield than the second season, In contrast, triticale and canola were winter-killed in the second year due to unusually dry and cold regional winter conditions, The model demonstrated moderate to high accuracy across species and years, and aligned within the ranges found in the literature review, but showed less efficacy under extreme conditions such as winter-kill

As we all know weather parameters such as precipitation and solar radiation largely dictate cover crop growth, but management practices such as planting and termination timing, as well as species selection, also significantly influence biomass production, We were interested to understand how growing interval impact the potential biomass production of a given species at a given location

Therefore, we coined the term, cover crop growth gap (βg) and calculated as the difference between maximum biomass yield under the extended growing intervals and the minimum biomass yield under shorter growing intervals, This gap represents the difference between the actual biomass yield achieved under shorter growing intervals and the potential biomass yield under extended growing intervals, This growth gap is analogous to commonly used methods in the literature for estimating yield gap (i.e., potential yield compared to actual yield)

During analysis, we utilized a historical weather dataset spanning 37 years, In the figures on the left, extended interval is indicated with blue color, and shorter interval with green color. This growth gap was calculated for eight climatic divisions of Nebraska

On average, when planting in the shorter growing interval, the magnitude of gap ranged from a loss of 21% (north-central) to 53% (southwest) for wheat, 27% (north-central) to 67% (southwest) for rye, 23% (north-central) to 58% (southwest) for triticale, and 20% (northeast) to 43% (southwest) for canola, compared to an extended interval

We were also interested to explore the impact of various planting and termination dates on biomass production within each county level, The analysis considered three planting dates: Mid-Sep (Sep14), Late-Sep (Sep 27), and Early-Oct (Oct 10), along with three termination dates: Mid-April (April 13), Late-April (April 26), and Early-May (May 09)

Results consistently showed increased biomass production with extended growing periods across all species, but here I am showing figure only for Rye, Specifically, planting from Mid to Late Sep and termination in Early-May of the following year, particularly in the southeast, northeast, east-central, and south-central regions, displayed the potential for higher biomass production

However, planting in Late-Sep to Early-Oct and terminating in Mid to Late April of the subsequent year, especially in the panhandle, north-central, and south-west regions, showed lower biomass yields across all species, Extreme cold temperatures, limited sunlight, and scarce water availability in these regions might have led to the lower biomass yields

If planting is delayed and termination is early, there is the potential to have a gap or loss of approximately 924 to 3386 kg/ha for wheat, 1197 to 4632 kg/ha for rye, 1009 to 3557 kg/ha for triticale, and 1210 to 4525 kg/ha for canola, These gaps underscore the critical impact of growing intervals on biomass production, This analysis highlights the potential biomass loss due to delayed planting and early termination, or the potential increase with early planting and delayed termination

This simulation study from eastern Nebraska tested various rye planting dates in the fall vs one termination date in the spring (April 14) over two years (2015 and 2016), Results showed that biomass production varied by planting dates, with the highest production for the earliest planting date in both years, For example, rye planted in 2015 and terminated in 2016 showed exceptionally high biomass, Earlier planting dates between mid-Sep and early Oct doubled the amount of biomass compared to late Oct planting dates for both the years, This highlights seasonal weather conditions make each year's CC growth uncertain

In the same study, cover crop growing season (Sep – April) were classified based on above or below average moisture and temperature, cool and dry means <15 ^{0}C and <225 mm rainfall, warm and dry means >15 ^{0}C and <225 mm rainfall, cool and wet means <15 ^{0}C and >225 mm rainfall, and warm and wet means >15 ^{0}C and >225 mm rainfall

Rye spring biomass was generated for planting dates starting from Sep 15 to Oct 31 using historical weather dataset that were factored in the weather variabilities, Rye was terminated on April 15 irrespective of the planting dates

Earlier planting accrued exceptionally high biomass in warm-wet seasons, moderate biomass in cool-wet and warm-dry seasons, and low biomass in cool-dry seasons, Ten times more biomass was observed when planted in mid-Sep compared to late-Oct, For identical planting dates, a warm-wet season produced approximately four times more biomass than a cool-dry season, On an average, during a six week fall planting window (Sep 15–Oct 31), every day before Oct 31 that the rye was planted resulted in additional 55 lbs./ac of biomass, And averaged across all seasons, delaying rye planting from mid-Sep to Oct-end resulted in a loss of biomass by 89%

That study also tested a range of termination dates to determine how delaying termination in spring might affect rye biomass, with the consideration of seasonal weather variability, Rye spring biomass was generated for termination dates starting from April 1 to April 30, Rye was planted on Oct 10 irrespective of termination dates, There was no differences in biomass yield between warm-dry and cool-wet season for any of the termination date, Four times more rye biomass was observed when terminated in April end versus April first, Every-day delay in rye termination resulted in an additional biomass of 31 lbs./ac per day, And when averaged across all seasons, delaying rye termination from April 1 to April 30 resulted in an increase of biomass by 284%

In this slide, I would like talk about how planting practice influence biomass yield, This study was conducted in 2014 through 2018 in eastern Nebraska at three sites, Planting practices were pre-harvest broadcast inter-seeding in corn and soybean stands in Sep, and post-harvest drill seeding after corn and soybean harvest in Oct–Nov, All experimental plots were in no-till management, cover crops were broadcasted when corn had reached R5.5 stage and soybean was at R6 or R7, cover crops were terminated at following spring in Mid-April, which was 2 wks. before planting corn or soybean

Results showed that at the sites with wet fall weather, pre-harvest broadcasting increased biomass by 90%, to 1.29 Mg ha^{-1} for RYE and 0.87 Mg ha^{-1} for MIX1 in soybean–corn, and to 0.56

Mg ha^{-1} and 0.39 Mg ha^{-1} in corn–corn, respectively, At the drier site, post-harvest drilling increased biomass of RYE and MIX1 by 95% to 0.80 Mg ha^{-1} in soybean–corn, This points out that early planting, combined with warm temperatures and relatively high precipitation in fall through spring can improve biomass production compared to cold or dry fall and spring and minimal snowfall

In this slide, I wanted to talk about how biomass production can differ between years within the same site and growing conditions, This study was conducted at Sidney, Nebraska during the 2012 and 2013 growing seasons under both rainfed and irrigated conditions, Study location had a silt loam soil, The cropping system investigated was a no-till proso millet–spring cover crop–winter wheat rotation, All treatments were no-till seeded into proso millet residue left following proso millet harvest the previous Sep

I would like to highlight the percentage change brought by irrigation over dryland, you can see in 2012, for example, irrigation brought like 47% more biomass compared to dryland for the flax. But you can see the average biomass production indicated in a green color like in 2012 dryland has average production of 2,184, whereas in the same study site, in 2013 there was an average production of 4,224, and similarly, for irrigated sites as well, there was differences in biomass production between years. This study showed that cover crops planted on near-identical dates in consecutive years did not yield similar biomass, given year-to-year variability in weather conditions

These are photos of fall-planted rye in Scottsbluff, Nebraska for the 2023-2024 growing season, I chose rye because it is a common cover crop in this region, The purpose of these pictures is to demonstrate how visual appearance, or assessments can provide quick biomass estimates in the field without destructive sampling

We clipped aboveground samples in a 2 ft by 1 ft quadrat, dried, and measured biomass in kg/ha, Across all these photos, plant height and plant density or canopy coverage differ. I would like to draw attention to the fact that plant height and density can tell the story of biomass estimates, Left photo: 25% ground cover (sparse vegetation, visible gaps) Middle photo: 66% ground cover Right photo: 90% ground cover (thicker growth, no visible gaps), The message is that taller plants with higher ground coverage typically results in more biomass yield

Elbon rye is similar to the height, but they differ in ground cover. Higher cover resulted in higher biomass yield, I would also like to stress that different cover crop families (e.g., legumes vs. grasses) can produce different biomass even if ground coverage looks similar

I'm giving a summary of the research evidences that I talked, Cover crop planted by mid-Sep produced ten times more biomass than those planted in late-Oct, with termination occurring in mid-April, Delaying spring cover crop termination from early to late April increased biomass production by four times for cover crops planted in early-Oct, A warm-wet growing season can produce four times more rye biomass compared to a cool-dry season, Biomass production ranged from 110 to 6710 kg ha^{-1} for wheat, 190 to 6310 kg ha^{-1} for rye, 750 to 7160 kg ha^{-1} for triticale, and 100 to 2200 kg ha^{-1} for canola, Extended growing periods, particularly with early planting (mid-Sep) and late termination (early-May), produced greater biomass by 158% for wheat, 112% for rye, 131% for triticale, and 247% for canola compared to shorter growing intervals (early-Oct to mid-April)

Take-home message, Year-to-year weather variability can affect biomass yields, even with cover crops planted on similar dates, Setting realistic biomass goals is essential, especially considering the harsh winter conditions that can limit productivity, Adjusting planting and termination timing (focusing on a longer interval such as mid-Sep to early May rather than early Oct to mid-April) can help maximize biomass yields under diverse environmental conditions in Nebraska

So, with this, I would like to wrap up my talk here, we will move to breakout rooms discussion.