DEPARTMENT OF PLANT AND SOIL SCIENCES

Student Research Abstracts

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COMPARISON OF IMAGERY-DERIVED WHEAT PHENOTYPES GENERATED BY MULTIPLE ORTHO-MOSAICKING SOFTWARE PIPELINES

Sanju Shrestha and Phillip D. Alderman

ABSTRACT

Accurate and efficient vegetation index (VI) generation is crucial for high-throughput phenotyping in wheat breeding programs. This study evaluates the performance of OpenDroneMap (ODM), Agisoft Metashape (Metashape), and Pix4DMapper (Pix4D) software in processing multispectral and RGB imagery collected from wheat breeding trials in Stillwater and Lahoma sites. Using datasets captured at multiple time points, we compare vegetation indices, including NDVI, NDRE, GNDVI, EVI, DVI, GLI, VARI, and EXG across three software platforms. Differences in reflectance calibration, radiometric corrections, and orthomosaic generation are assessed to determine their impact on data accuracy and consistency. Additionally, the extracted VI metrics are validated against ground truth disease ratings and yield data to assess their predictive capabilities for wheat performance. All VI analyses showed strong agreement (correlation >0.99, low RMSE 0.004-0.03), with minimal differences across software, although DVI, EVI, and ExG exhibited slightly higher RMSE (0.1-0.3), while rank and Pearson correlations remained above 0.97. Disease severity predictions using multinomial logistic regression were similar at lower levels but diverged slightly at higher severities, where Pix4D achieved the highest accuracy, while ODM excelled in BYD severity 2 predictions. The Spearman's rank correlation between all vegetation index (VI) combinations derived from the software and ODM-derived NDVI consistently surpassed 0.8, with macro precision deviating within ±0.04 of normalized ODM values across all VIs. Generalized Linear Model (GLM) for yield prediction demonstrated strong consistency across software platforms. Pix4D achieved marginally higher R^2 values for NDVI, DVI, and EVI, while OpenDroneMap (ODM) and Agisoft Metashape performed comparably, except for EVI, where their R^2 values showed a 6–8% difference. Standard deviation analysis of within-plot VI variation showed strong agreement (>0.85) for RGB-based indices, while NDRE exhibited slightly greater variability. Overall, Pix4D demonstrated marginally higher

accuracy in disease severity predictions at higher severities, ODM performed better in specific cases, and Metashape performed slightly better than ODM. However, these differences were minimal, suggesting that all three software platforms are viable options for UAV-based wheat phenotyping.

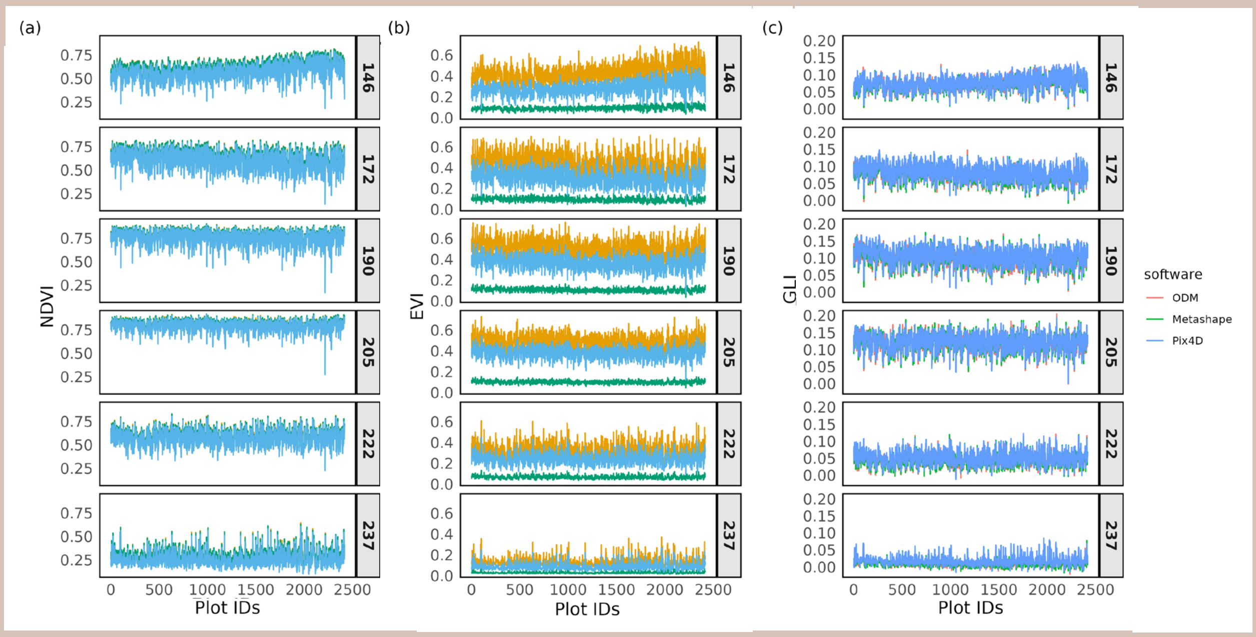

Figure 1: Vegetation indices across the season derived from multispectral imagery using ODM, Metashape, and Pix4D in Stillwater site. (a) NDVI (b) EVI (c) GLI trends

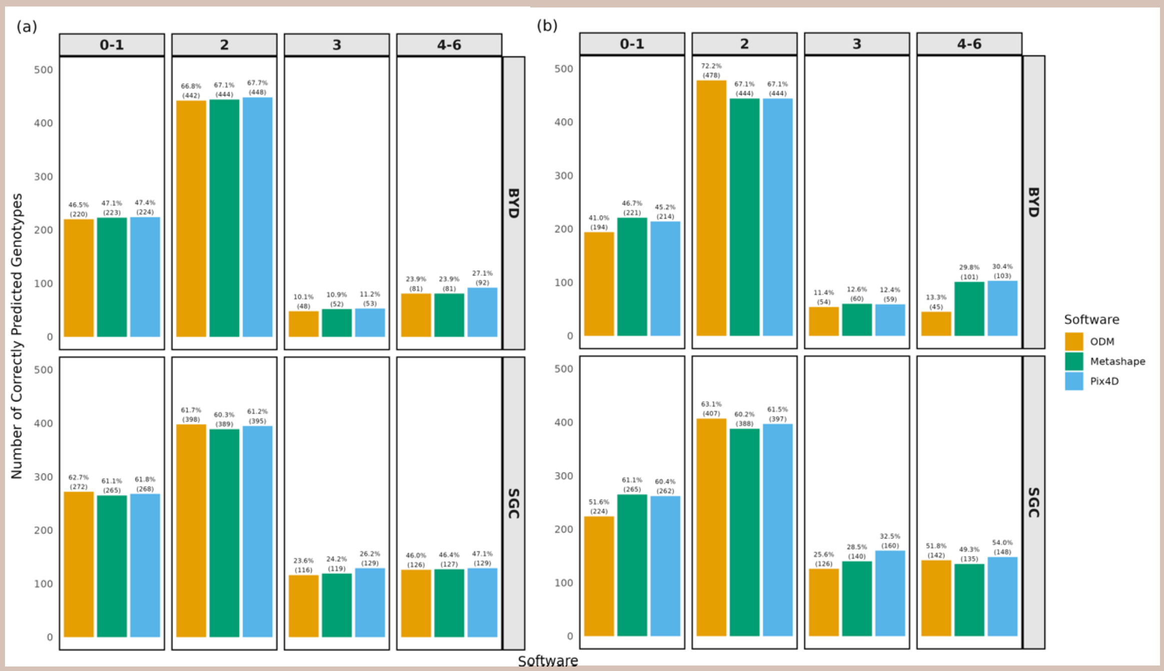

Figure 2: Software performance in correctly identifying genotypes for BYD and SGC. The plot is faceted by disease category (BYD or SGC) and severity levels (0-1, 2, 3, 4-6). The y-axis represents the number of correctly predicted genotypes, indicating software accuracy, while the x-axis represents the software type (ODM, Metashape, Pix4D). (a) Predictions using NDVI, (b) Predictions using EVI

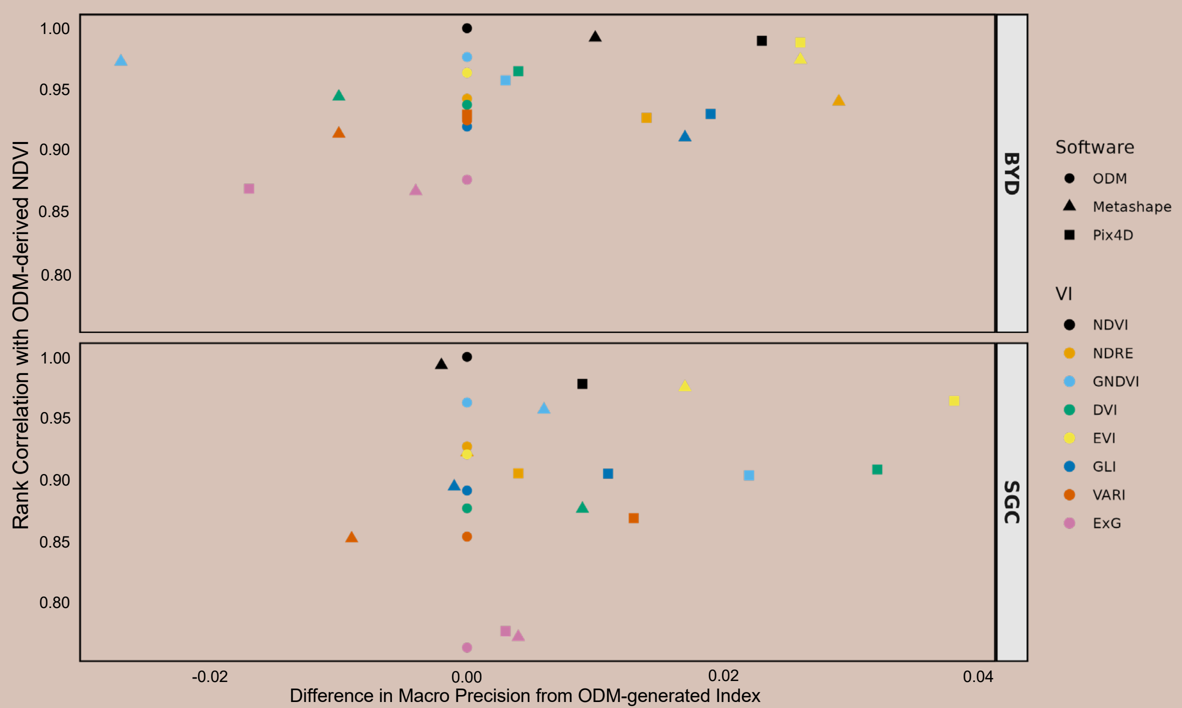

Figure 3: Comparison of macro-precision and rank correlation of genotype predictions across three software packages—ODM, Metashape, and Pix4D—for BYD (top) and SGC (bottom). Each point represents a genotype, with different symbols and colors corresponding to varying disease severity categories. The x-axis displays the difference in macro-precision from the ODM-generated index, while the y-axis shows the rank correlation with ODM-derived NDVI. Higher macro-precision indicates better genotype prediction compared to the ODM-generated index, and variations in rank correlation reflect differences in genotype ranking among the software packages relative to ODM-derived NDVI.

Conclusion

This study demonstrates that OpenDroneMap, Agisoft Metashape, and Pix4DMapper offer comparable and reliable solutions for vegetation index generation and yield prediction in UAV-based wheat phenotyping. Despite minor variations in disease severity prediction accuracy, particularly with Pix4D performing better at higher severities and ODM excelling in BYD severity 2 predictions, all three platforms exhibit strong agreement in VI calculations and yield modeling. While Pix4D showed slightly higher R^2 values for some yield predictions and the RGB-based indices were strongly aligned, the overall minimal performance differences suggest that all three software packages are suitable for high-throughput wheat phenotyping. Considering these results and the added benefit of being free and open-source, OpenDroneMap presents a compelling alternative, providing researchers with flexibility in platform choice based on workflow preferences and budget considerations.

PHYSICAL PROPERTIES AND GREENHOUSE GAS EMISSIONS IN A LONG-TERM WHEAT FERTILITY STUDY

Tyler Steichen, Sergio Abit, D. Brian Arnall, and Sumit Sharma

ABSTRACT

Long-term field studies have been vital sources of information on the effects of amendments on soil properties because they account for natural variability and complexities of experimental conditions over time. This study was conducted to evaluate the effects of soil fertility amendments on soil physical and chemical properties and greenhouse gas emissions at a long-term continuous wheat soil fertility experiment which was established in 1892 in the Oklahoma prairie soils. Samples for analysis of soil chemical and physical properties were collected prior to planting of the 2023 wheat crop while the analyses of some physical properties were performed in situ. Collection of gas samples for greenhouse gas (GHG) analysis were performed within the 17-month study period. Manure application led to higher pH and soil organic matter (SOM) content. Continued P and K applications seemed to cause their accumulation on the surface while N application seemed to cause nitrate leaching all the way to the 45 cm depths. Although there were observed trends in treatment effects on physical properties, most were not statistically different likely be due to the overwhelming tendency of continuous conventional tillage to homogenizing soil physical properties. Carbon dioxide and nitrous oxide emissions were influenced by the by soil temperature and rainfall. Carbon dioxide and nitrous oxide emissions were appreciably higher in the N-applied and the manure treatments. The study showed that long-term continuous fertilizer application influenced greenhouse gas emissions, soil physical and chemical properties as well as the distribution of nutrients in the soil profile.

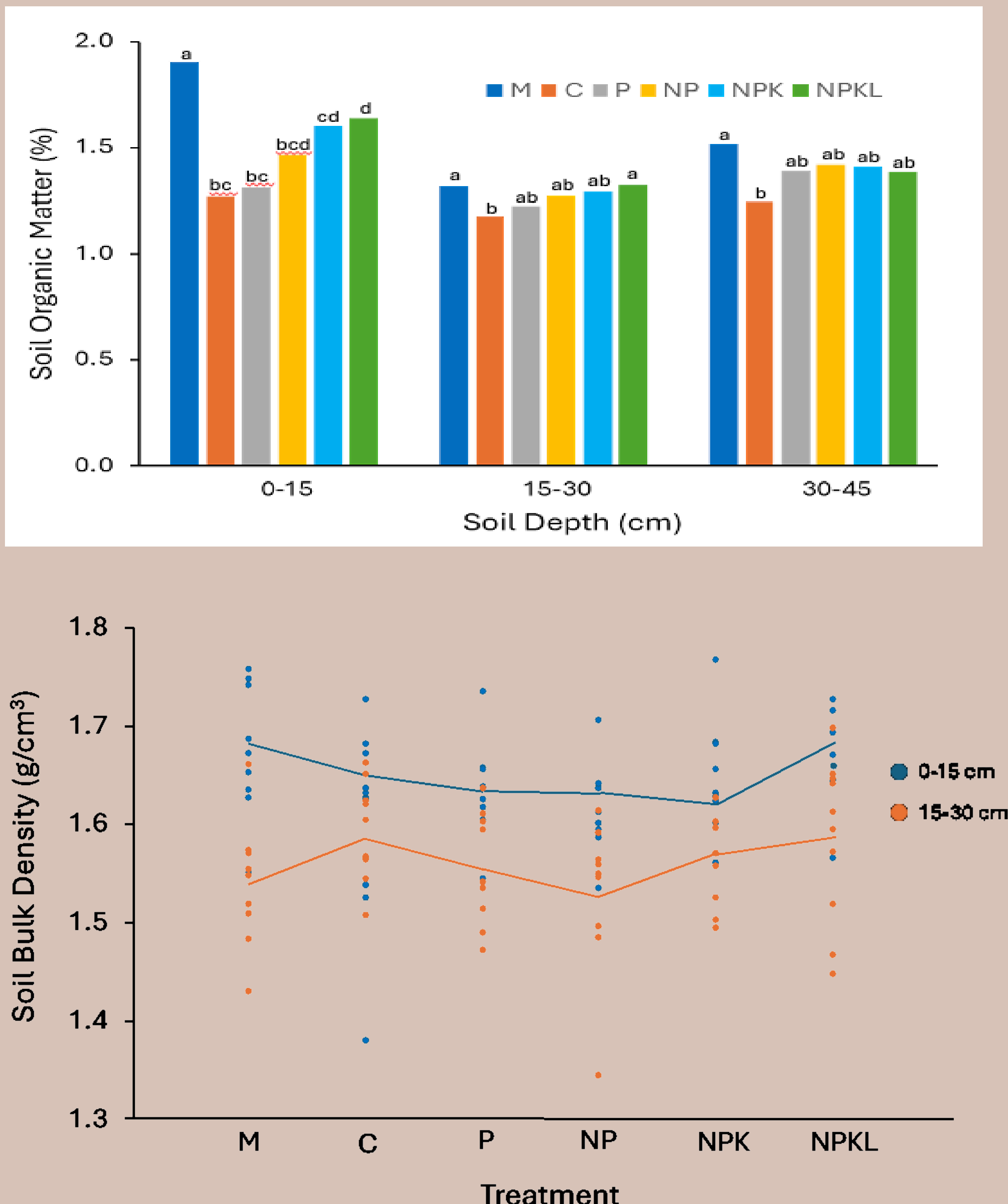

Figure 1. Pre-plant soil organic matter content of different treatments at the Magruder Plots.

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Figure 2 Bulk trends of bulk density in the different treatments along with the surface and subsurface of the Magruder Plots

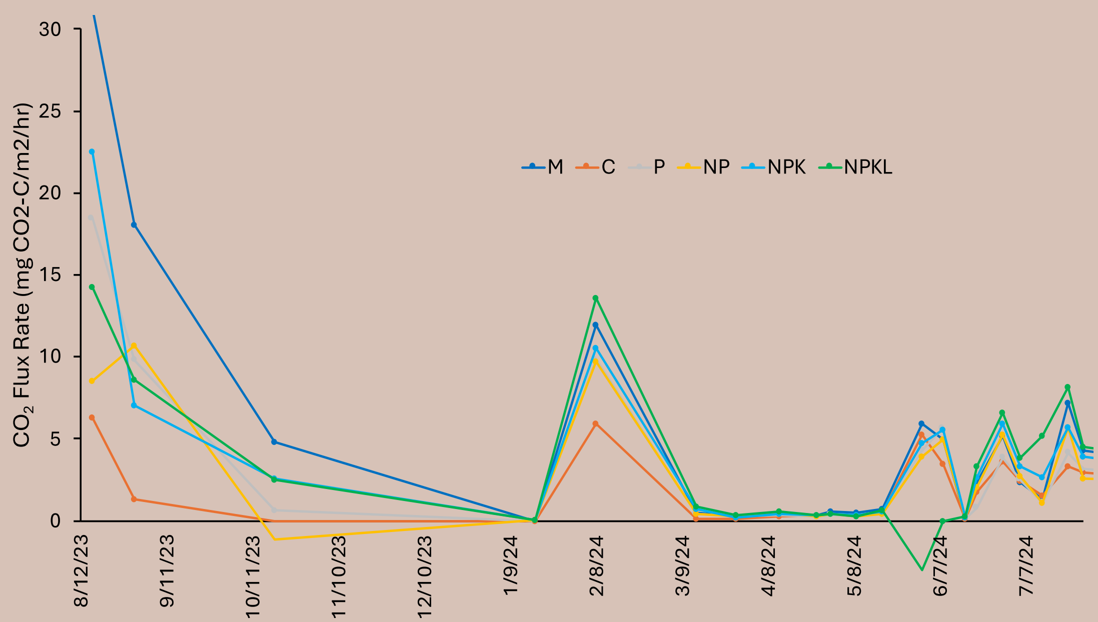


Figure 3 The average flux in of CO_2 emissions per sample in each treatment of the Magruder plots from August 2023 to August 2024

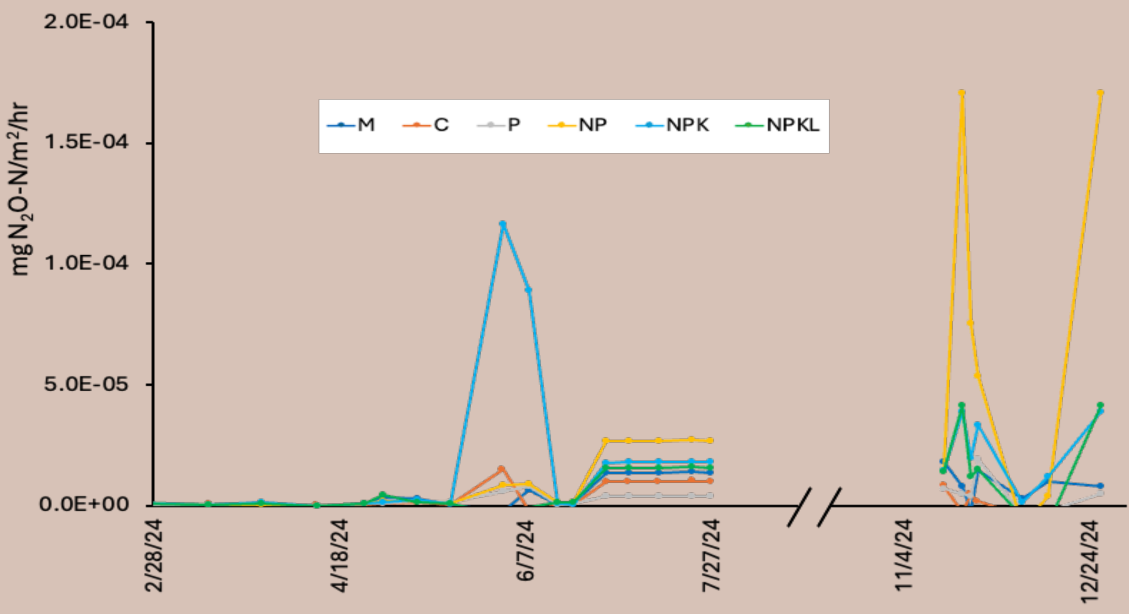


Figure 4 The average flux in of N_2O emissions per sample in each treatment of the Magruder plots from February 16, 2024, to December 27, 2024

Conclusion

Soil organic matter content played a key role in shaping the chemical and physical properties, as well as greenhouse gas emissions, across the six treatments in the Magruder Plots. However, in some cases, continuous tillage disrupted soil structure to the extent that organic matter had little impact on physical properties. Greenhouse gas emissions are expected to rise significantly when soil temperatures exceed 20°C and following rainfall events.

ANTHOCYANIN YIELD & STABILITY IN PIGMENTED WHEAT

Everett G. Daugherty, Brett F. Carver and Edralin A. Lucas

ABSTRACT

Malnutrition has long hindered man's quality of life. Given wheat's indispensable role in the human diet, the modern wheat breeder thus undertakes a unique responsibility: that is, the obligation to select not simply for traits germane to the livelihood of agriculturalists, but also for those that augment the diet quality of the likely unaware consumer. While numerous approaches exist for enhancing the nutritional value of wheat, improvement by selection for anthocyanin production is among the most promising, thanks to these compounds' ability to decrease inflammation & oxidative stress through the diet. This study quantifies the anthocyanin content of purple & blue bread-wheat breeding lines across multiple environments, using both the traditional methanol-extraction method—which precisely measures pigment concentration in flour—as well as a newer, more efficient *colorimetric* method, which ascertains anthocyanin concentration through photographic color coordinates of whole grains. The data (& the linear models that derive from them) demonstrate that there is significant correlation between simple colorimetric analysis of bran color & the anthocyanin concentration that the methanol-extraction procedure more accurately measures, meaning that colorimetric analysis may be an inexpensive yet reliable alternative. The results also indicate that blue genotypes may produce anthocyanin concentrations three to four times higher than that of this assay's most anthocyanin-rich purple wheat (16 $\mu g\ g^{-1}$). Furthermore, the multi-environment dimension of this experiment provides insight into genotype-environment interactions which no similar publication has yet investigated.

Figure 1: Mean Purple-Wheat Genotypes' Anthocyanin Concentrations (µg/g) vs. b* (blueness)

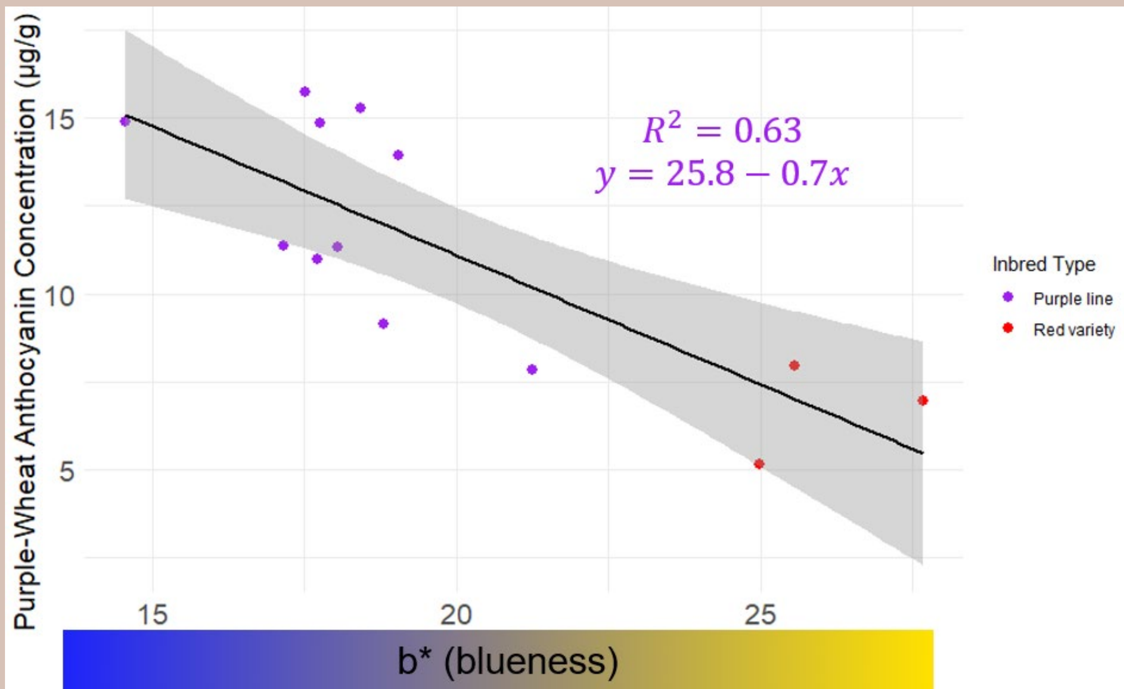
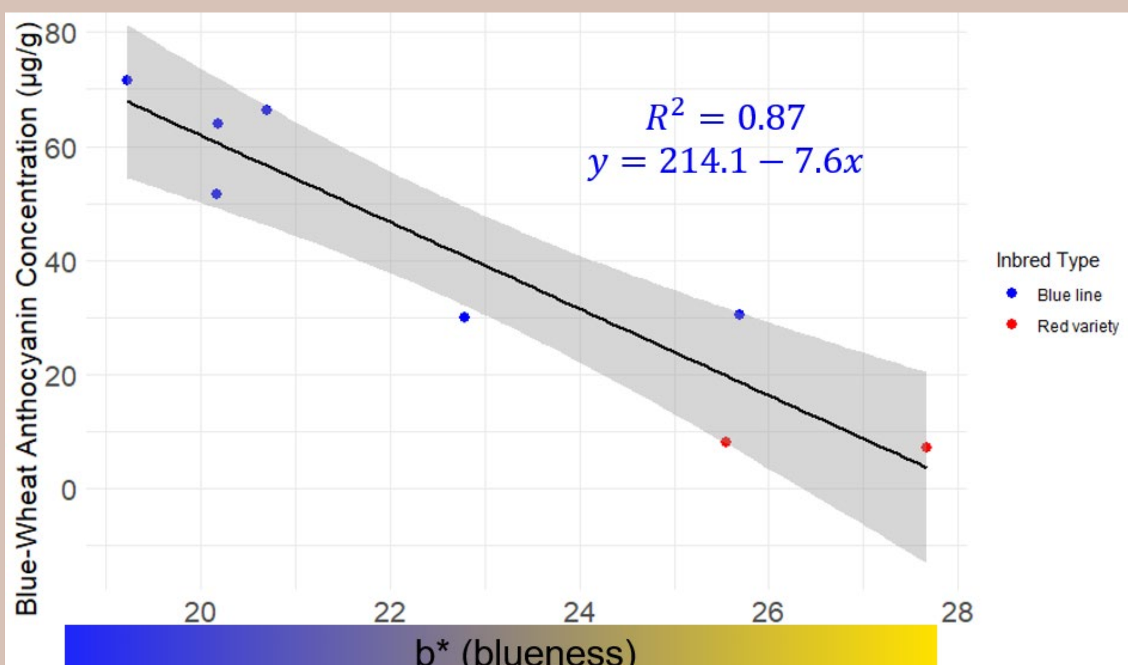


Figure 2: Mean Blue-Wheat Genotypes' Anthocyanin Concentrations (µg/g) vs. b* (blueness)



Conclusion

Both blue & purple wheat anthocyanin concentrations exhibited significant ($p<0.001$) moderate, negative correlation with colorimetric b*(blueness) values. Purple genotypes showed greater dispersion in anthocyanin concentration in the lower b* range. Though this study recorded all axes of the color space, the L* (darkness) & a* (verdancy) axes did not strongly correlate with the true anthocyanin concentration. The anthocyanin extractions also revealed that blue wheat may produce over 70 μg g^{-1} total anthocyanins, while the highest mean concentration for purple wheat in this sample set was 16 μg g^{-1}.

The above linear models now allow the approximation of anthocyanin content in any wheat sample with moderate confidence, using nothing more than a colorimeter. This technique will make the selection process more efficient, especially in earlier inbreeding generations, as the tedious methanol-extraction method is no longer the only available procedure for the wheat-breeding program. This method also facilitates evaluating genotype-environment interactions & grain-weathering effects, which can provide valuable insight into genotype stability throughout Oklahoma.

There are many possible limitations to colorimetry (*viz.* breeding-line contamination, *Fusarium* head blight, common bunt, insects & insect damage). This study's procedures attempted to minimize these error risks by recording a sample's colorimetric value as the mean of ten scans. However, using clean samples is the most effective solution. For the above models, mechanical damage that exposes endosperm may be the greatest threat to their integrity, as it interferes only with the colorimeter values—not with the anthocyanin-extraction results.

Future investigations may examine whether other color spaces be better suited to different pigmentations; this could potentially ameliorate the lower correlation for the purple-wheat model, compared to its blue-wheat counterpart. Black wheat (which combines purple-pericarp & blue-aleurone traits) should also require investigation for its immense anthocyanin-yielding potential. Black wheat breeding lines are in the earlier development stages of our breeding program, but they will nonetheless receive future attention.

These methods may even be applicable for evaluating anthocyanin content in purple & blue bread products. Such tests could be useful for bakers and industry professionals, especially during product development, as various baking methods may have different impacts on the final anthocyanin concentration in food products.

DELAYED-SOWN WINTER WHEAT: THE ROLE OF SHORT-SEASON GENOTYPE AND SEEDING RATE

Israel M. Cyrineu, Gustavo A. Slafer, Brett F. Carver, and Amanda de Oliveira Silva

ABSTRACT

Climate change is intensifying extreme weather events, especially during winter wheat sowing in the US Southern Great Plains. Floods and droughts are forcing farmers to delay sowing, emphasizing the need for management practices and resilient genotypes adapted to delayed sowing. Our objectives were to (i) quantify yield responses of a substantively delayed sowing relative to the currently standard practice in the Southern Plains, (ii) examine genotypic responses to delayed sowing, (iii) determine whether increasing seeding rate would benefit yield, particularly with delayed sowing, and (iv) evaluate the physiological traits associated with yield responses to delayed sowing. Field experiments were conducted at two locations and in three growing seasons in Oklahoma, using eight full-season winter wheat genotypes and one short-season genotype (Butler's Gold), sown at two dates (standard, mid-October, and delayed, early-December) and two seeding rates (recommended and higher). Delayed sowing did not differ in yield with standard sowing averaged across site-years. Butler's Gold matured six days earlier than full-season genotypes. Although it did not surpass full-season genotypes in yield, it produced heavier grains and higher protein concentration. Increasing the seeding rate did not improve yield with delayed sowing. Biomass at maturity and grain number per unit area were the main physiological traits associated with yield increase at delayed sowing (r^2=0.93, $P<0.001$ and r^2=0.88, $P<0.001$, respectively). Butler's Gold provides adaptability to abbreviated growing seasons, enabling double cropping. These findings emphasize the importance of targeted management practices and breeding strategies to optimize winter wheat production in delayed-sown conditions amidst a changing climate.

Yield for each genotype at standard and delayed sowing, and the difference between them, averaged across two sites, three years, and two seeding rates. The table also includes the average of all genotypes, the significance of genotypic differences within each sowing date, and the Tukey's Honestly Significant Difference (HSD (0.05)) when the p-value was significant are also shown. "ns" indicate no statistically significant difference.

	Sowing date				
	standard		delayed		difference
Genotype	yield ($Mg\ ha^{-1}$)				
Butler's Gold	3.9	B	4.2	B	0.3
Baker's Ann	4.0	B	4.3	AB	0.3
Bob Dole	4.3	AB	4.9	A	0.6
Skydance	3.7	B	4.4	AB	0.6
Green Hammer	4.3	AB	4.7	AB	0.4
OK Corral	4.7	A	4.7	AB	0.0
Showdown	4.1	AB	4.6	AB	0.5
Gallagher	4.4	AB	4.7	AB	0.3
AM Cartwright	3.8	B	4.4	AB	0.6
Average	**4.1**		**4.5**		**0.4**
p-value	**<0.001**		**<0.01**		**0.65**
HSD (0.05)	**0.7**		**0.6**		**ns**

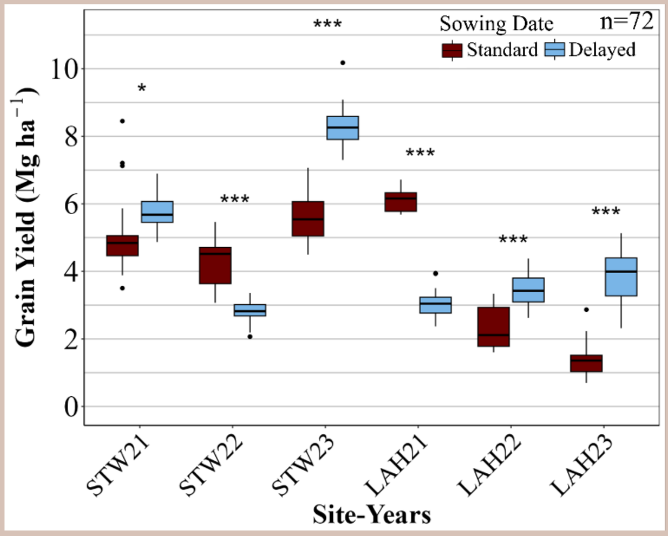


Fig. 1. Box plots of yield for standard and delayed sowing dates averaged over seeding rates and genotypes for each site-year. STW, Stillwater; Lah, Lahoma; 21, 2020-2021; 22, 2021-2022; and 23, 2022-2023. N= number of observations within each box plot. Asterisks represent the statistical significance of the difference between standard and delayed sowing dates: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Conclusion

- Delayed-sown winter wheat showed no consistent yield loss compared to standard-sown.
- The short-season genotype did not outperform the other genotypes at delayed sowing.
- No benefit was found by increasing the seeding rate with delayed sowing.
- Genotypes with higher biomass and grain number performed better in delayed sowing.

Comparison of Vegetation Indices Calculated Pre and Post Ortho-Mosaicking of UAS-Based Wheat Imagery

Grishma Ojha, Sanju Shrestha, and Phillip D. Alderman

ABSTRACT

The conventional approach of image ortho-mosaicking (stitching) involves pixel merging and blending which can potentially alter pixel-level information, leading to inaccuracies in calculated Vegetation Indices (VIs). This study proposes an alternative approach of VI calculation prior to stitching of UAV-based multispectral imagery and compares it with the conventional approach. Multispectral images were captured using the DJI Phantom 4 drone. Three VIs, Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation Index (GNDVI), and Normalized Difference Red Edge (NDRE), were used for the comparison. Image stitching was performed using OpenDroneMap (ODM). Genotype ratings, based on visual assessment for Barley Yellow Dwarf (BYD) disease and Stay Green Canopy (SGC) traits, were used for ground truthing. Multinomial Logistic Regression (MLR), Pearson's correlation, and Spearman's rank correlation were used to quantify the differences between the approaches. The results showed a higher correlation between approaches during mid-season and a lower correlation during the start and end of the growing season for winter wheat. The correlation ranged from 0.65 to 0.95 for NDVI, 0.43 to 0.96 for NDRE, and 0.64 to 0.95 for GNDVI. In addition, the VIs calculated using proposed approach showed lower rank correlation with the conventional approach NDVI compared to GNDVI and NDRE calculated using conventional approach. Furthermore, the comparison of MLR models trained using all combinations of VIs as predictors, along with BYD ratings and SGC ratings as response showed that, the proposed approach had higher precision compared to conventional approach for predicting SGC ratings. However, both approaches performed poorly in predicting BYD ratings.

Results

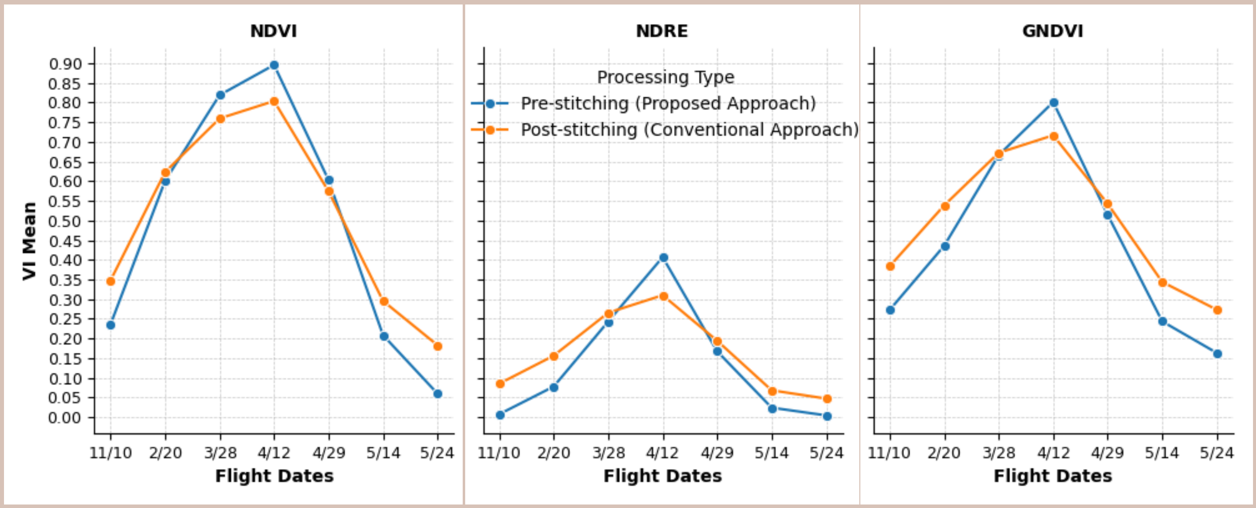


Figure – 1: Average VI values calculated using two approaches for the experiment site at different stages of growth

Figure –1 shows the average value of VIs for the entire experimental field at Stillwater for 2023-2024 season. For all the VIs, the field-average values were higher for the proposed approach during mid-season (April 12, 2024) slightly lower during early (November 10, 2023) and late season (May 24, 2024), compared to values calculated using conventional approach lower during start and end of the season.

Hence in the level of entire field, there are differences between the values of VIs at different stages in the season. Higher values of VIs for proposed approach during mid-season and lower values during early and late season also indicated higher sensitivity or responsiveness of proposed approach to changes in canopy properties during key growth stages.

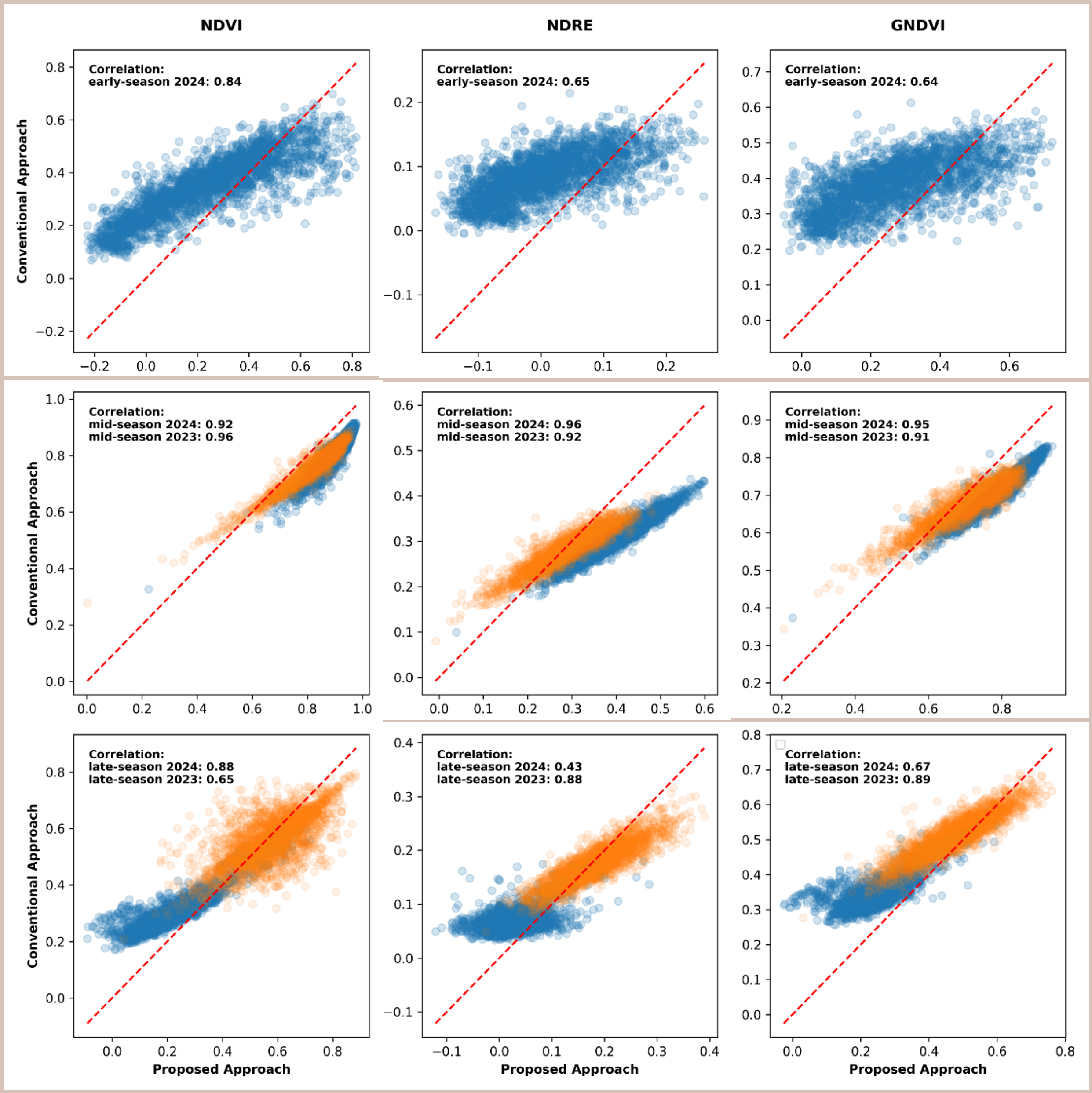


Fig – 2: Scatterplot representing plot-level average VI values (NDVI, GNDVI, NDRE) across early, mid, and late growth. Overall, Weaker correlation was observed between the approaches across all the indices early and late in the season, with higher correlation during mid-season.

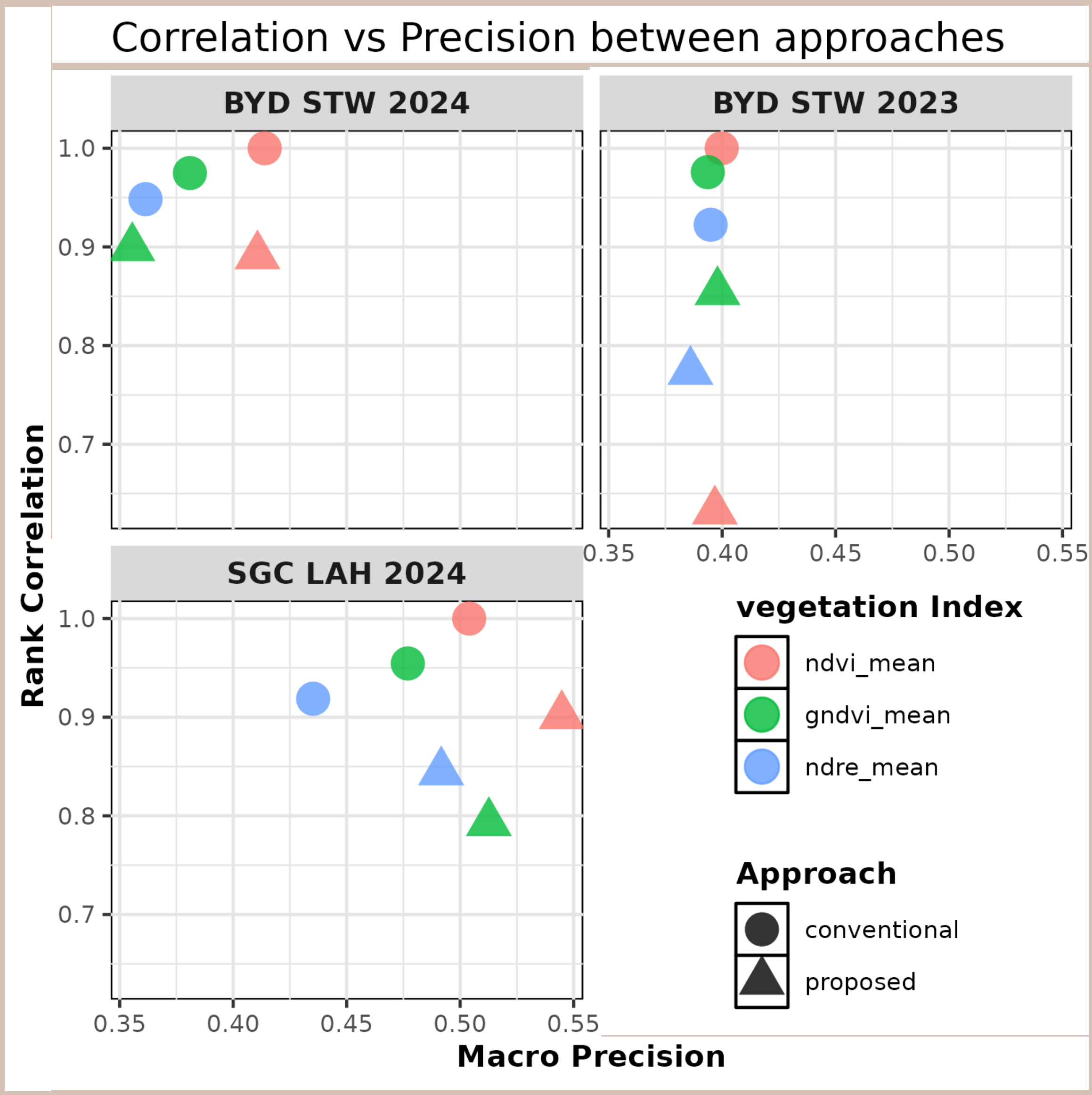


Fig – 3: Rank correlation vs Macro-precision

The y-axis represents the rank correlation between NDVI values calculated using conventional approach and rest of the indices (GNDVI, NDRE) calculated using conventional approach and VI calculated using proposed approach. Here, the conventional NDVI was used as a baseline to correlate all other indices with it. The x-axis represents the macro-precision of the models trained using the corresponding indices (NDVI, NDRE, GNDVI) as predictors and visual ratings (BYD and SGC) as response for both proposed and conventional approach

Conclusion

This study shows that there are differences between the Vegetation Indices (VIs) calculated before after image stitching. The proposed approach was more responsive to the changes in vegetation conditions. The proposed approach produced higher values of VI during mid-season and lower values during early and late season compared to conventional approach. In addition, the proposed approach was slightly better at predicting the growth reference Stay Green Canopy (SGC) ratings compared to the conventional approach. Lower rank correlation was consistently observed between the conventional and proposed approaches for all the VIs. However, pixel level analysis would result in more detailed comparison between the approaches and which approach of ortho-mosaicking preserves most of the structural information in the raw image, leading to accurate calculation of VIs.

EVALUATION OF N SOURCE AND TIMINGS IN NO-TILL WINTER WHEAT

Jolee Derrick, Amanda de Oliveira Silva, Steve Phillips, and D. Brian Arnall

ABSTRACT

Nitrogen fertilizer efficacy is largely dependent upon the application timing and surroundings in which they are placed. Therefore, the variability in Oklahoma's environmental and meteorological conditions can present a distinctive challenge for the state's agricultural producers looking to apply nitrogen fertilizers in their no-till production systems. This study examines the effects of nitrogen source and application timing on winter wheat grain yield and protein content in no-till systems. Over 11 site-years, four N fertilizers—urea, urea-ammonium nitrate (UAN), SuperU, and UAN + Anvol—were applied at a rate of 66 kg ha^{-1} across three physiological timings. Due to significant variability between growing seasons, Dunnett's analysis was used to assess the impact of nitrogen source and timing on grain yield and protein percentage for each growing season. Urea consistently outperformed other N sources in terms of grain yield and protein concentration. Across site years and stages, no significant benefit was observed for the addition of nitrogen stabilizers. Feekes stages correlated with a late February/early March application period maximized grain yield, while later applications resulted in higher protein content. These findings suggest that late February/early March urea applications can optimize yields for Oklahoma winter wheat producers.

INTERACTIVE EFFECTS OF P AND K APPLICATION TIMING AND SOIL MOISTURE VARIABILITY IN WHEAT-SOYBEAN DOUBLE CROPPING SYSTEMS

Chisom Ejezie and Steve Phillips

ABSTRACT

Double cropping wheat and soybean offers a potential method of intensifying land use and maintaining productivity in water-limited regions, such as Oklahoma. However, we have limited knowledge about the interactions between phosphorus (P) and potassium (K) fertilizer timing and in-season soil moisture fluctuations in double cropping systems, which hinders our ability to develop site-specific nutrient management recommendations. This study aims to investigate how the timing of P and K fertilizer application interacts with in-season soil moisture conditions to influence yield stability in a wheat–soybean double cropping system. From 2024 to 2026, a field trial will be conducted at the Lake Carl Blackwell Research Station using a split-split plot design that includes four fertilizer application timings (fall, winter, spring, and summer) and six P and K treatment strategies across four replicated wheat–soybean sequences. Soil moisture content will be assessed continuously using in-situ soil moisture sensors. We hypothesize that synchronizing fertilizer application with timing of soil moisture will significantly stabilize yield compared to a typical pre-plant application. By explicitly examining soil moisture dynamics across different application timings, this research fills a significant void in existing recommendations, and outlines strategies for sustainable intensification, benefiting all producers in the southern Great Plains and similar agroecological environments. The results from this study will be used to inform climate-smart and economically balanced nutrient recommendations for wheat-soybean cropping systems that advance sustainability knowledge in extension.

NITROGEN UPTAKE DYNAMICS OF HIGH AND LOW PROTEIN WHEAT GENOTYPES

Samson Olaniyi Abiola, Josefina Lacasa, Brett F. Carver, Brian D. Arnall, Ignacio A. Ciampitti, and Amanda de Oliveira Silva

ABSTRACT

Increasing wheat (Triticum aestivum L.) yield and grain protein concentration (GPC) without excessive nitrogen (N) inputs requires understanding the genotypic variations in N accumulation, partitioning, and utilization strategies. This study evaluated whether high protein genotypes exhibit increased N accumulation (herein also expressed as N nutrition index, NNI) and partitioning (including remobilization from vegetative organs) compared to low-protein genotypes under low and high N conditions. Four winter wheat genotypes with similar yields but contrasting GPC were examined under two N rates (0 and 120 kg N ha-1) across two environments and four growing seasons in Oklahoma, US. As expected, the high-protein genotypes Doublestop CL+ (Dob) and Green Hammer (Grn) had greater GPC than the medium- (Gallagher, Gal) and low-protein genotypes (Iba), without any difference in grain yield. Total plant N accumulation at maturity showed diminishing increases for greater grain yield, and low-protein genotype showed greater N utilization efficiency (NUtE) than high-protein genotypes. The high-protein genotype Grn tended to achieve higher GPC by increasing total N uptake, while Dob exhibited a tendency towards higher N partitioning to grain (NHI). The allometric relationship between total N accumulation and biomass remained unchanged for both high- and low-protein genotypes. The N remobilization patterns differed between high- and low-protein genotypes. As N conditions improved, the proportional contributions of remobilized N from leaves tended to increase, while contributions from stems and chaffs tended to decrease or remained unchanged for high-protein genotypes. This study highlights the importance of both N uptake capacity and efficient N partitioning to the grain as critical traits for realizing wheat's dual goals of higher yield and protein. Leaf N remobilization plays a critical role during grain filling, sustaining plant N status and contributing to protein levels. The higher NUtE observed in the low-protein genotype Iba likely contributed to its lower GPC, emphasizing the trade-off between NUtE and GPC. The physiological strategies employed by high-protein genotypes, such as genotype Grn's tendency for increased N uptake and Dob's efficient N

partitioning, provide a foundation for future breeding efforts aimed at developing resource-efficient and nutritionally superior wheat genotypes capable of achieving both increased yield and protein.

Citation: Abiola SO, Lacasa J, Carver BF, Arnall BD, Ciampitti IA and de Oliveira Silva A (2024) Nitrogen uptake dynamics of high and low protein wheat genotypes. Front. Plant Sci. 15:1493901. doi: 10.3389/fpls.2024.1493901

ASSESSMENT OF GENOTYPIC VARIATION IN WHEAT NITROGEN USE EFFICIENCY USING NITROGEN NUTRITION INDEX

Samson Olaniyi Abiola, Josefina Lacasa, Brett F. Carver, Brian D. Arnall, Ignacio A. Ciampitti, and Amanda de Oliveira Silva

ABSTRACT

This study investigated the relationships between Nitrogen Nutrition Index (NNI) and yield components of four wheat genotypes with varying grain protein concentrations (GPC) in dryland conditions. A Bayesian hierarchical model was developed to examine genotype responses under two nitrogen (N) rates across two environments over four growing seasons in Oklahoma. Significant genotypic variations in N use efficiency (NUE) and yield component responses were observed. The low-GPC genotype Iba achieved high relative yields (>0.75) at NNI values as low as 0.4, indicating higher NUE under N-limited conditions. In contrast, the medium-GPC genotype Gal showed a more linear response, reaching maximum yields at higher NNI values (0.9 to 1.0). High-GPC genotypes Dob and Grn exhibited intermediate patterns with notable variability at mid-range NNI values. Critical NNI values for maximizing GPC (0.2 to 0.8) were generally lower than those for grain yield (1.0 to 1.2) across all genotypes. Low to medium-GPC genotypes achieved near-maximum GPC at NNI values of 0.2-0.4, while high-GPC genotypes showed a more pronounced response to increasing N conditions. Analysis of yield components revealed varying responses in spike count among genotypes. Iba rapidly increased spike count at lower NNI values, while Gal showed a more gradual increase. High-GPC genotypes Dob and Grn plateaued at higher NNI values. This study highlights the importance of considering genotype-specific responses when developing N management strategies and breeding programs to improve NUE in wheat. The findings suggest that breeding efforts should consider yield, protein potential, and NUE across a range of N availabilities to optimize both yield and protein outcomes while minimizing N losses in dryland wheat production systems.

OPTIMIZING SPRAY TECHNOLOGY AND NITROGEN SOURCES FOR WHEAT GRAIN PROTEIN ENHANCMENT

Samson Olaniyi Abiola, Raedan Sharry, Josh Bushong, and Brian D. Arnall

ABSTRACT

Increasing wheat (Triticum aestivum L.) grain protein concentration (GPC) without excessive nitrogen (N) inputs requires understanding the interactions between N source characteristics and application technology parameters. This study evaluated the effects of foliar N applications at anthesis on wheat grain yield and GPC across three locations over three growing seasons in Oklahoma. Treatments consisted of two N sources (urea-ammonium nitrate [UAN] and aqueous urea [Aq. urea]), three nozzle types (flat fan [FF],3D, and twin [TW]), and two droplet types (fine and coarse). Late foliar applications increased GPC by 12% without affecting grain yield (0.5–5.8 Mg ha−1). During the 2020–21 growing season, a late season freeze during anthesis resulted in no significant differences in GPC across locations. UAN produced a significantly higher GPC (13.7%) than Aq. Urea (13.1%). Among nozzle types, the 3D nozzle consistently produced the highest GPC (13.8%), compared to FF (13.1%) and TW nozzles (13.2%). Two-way interactions revealed UAN with fine droplets achieved consistently high GPC (14.6%), as did Aq. urea with coarse droplets (14.5%) at Lake Carl Blackwell in 2021–22 as compared to Aq. Urea fine (13.8%). At Chickasha 2021–22 and Perkins 2020–21, a significant three-way interaction was observed, with the UAN_3D_Fine (13.2%) and UAN_3D_Coarse (12.2%) treatments producing the highest GPC, with 8% and 15% greater than the Aq. Urea_TW fine, respectively, which is lowest. These findings provide a foundation for precision agriculture approaches that optimize foliar N application parameters to enhance wheat quality while maintaining sustainable production practices.

(PDF) Optimizing Spray Technology and Nitrogen Sources for Wheat Grain Protein Enhancement. Available from: https://www.researchgate.net/publication/390692633_Optimizing_Spray_Technology_and_Nitrogen_Sources_for_Wheat_Grain_Protein_Enhancement [accessed Apr 25, 2025].

WHEAT YIELD AND PROTEIN RESPONSE TO NITROGEN AND SULFUR MANAGEMENT

Samson Olaniyi Abiola and Brian D. Arnall

ABSTRACT

To optimize nutrient management strategies in wheat production (Triticum aestivum L.) for achieving high yield and grain protein concentration (GPC) in dryland environments, this study evaluated various nitrogen (N) and sulfur (S) management strategies. The approach began by examining the effects of different N rates (0, 50%, and 100% of 120 kg N ha^{-1}), followed by a comparison of pre-plant versus split applications (50-50% and 25-75% splits). Additionally, the study assessed late-season N applications at flag leaf and anthesis stages (25 kg N ha^{-1}) and the timing of S applications (11 kg S ha^{-1}) in relation to N splits and late-season applications. Research was conducted across five locations during the 2018-2023 growing seasons in Oklahoma and Kansas, USA. Pre-plant N at 100% of the required rate increased grain yield from 2.9 to 4.4 Mg ha^{-1} and GPC from 9.7% to 11.7% compared to the untreated control. Split applications (25-75% and 50-50%) improved both yield and GPC compared to single 100% pre-plant applications, with the 25-75% split achieving yields of 6.2 Mg ha^{-1} at Ballagh and 4.2 Mg ha^{-1} at Lake Carl Blackwell, representing increases of 15% and 11%, respectively. Late-season N applications exhibited location-specific responses, with anthesis timing consistently outperforming flag leaf applications, increasing GPC by 1.5-2.0% while maintaining grain yields between 4-6 Mg ha^{-1}. Combined N and S applications at anthesis achieved the highest GPC values (13-15%) while sustaining competitive yields, with GPC increasing by 3% and 2%, respectively, compared to split applications without late-season nutrients. This study underscores the significance of split applications and synchronized N-S timing as essential management practices for achieving the dual objectives of higher yield and GPC in dryland environments.

OPTIMIZING SEEDING RATE AND N MANAGEMENT FOR WHEAT VARIATIES

Samson Olaniyi Abiola, Brian D. Arnall, and Amanda de Oliveira Silva

ABSTRACT

This research investigates the effects of nitrogen (N) application rates, seed rates, genotypes, and N timing on wheat in Chickasha and Lahoma. A split-split plot design was employed, with N rates of 60 and 120 lbs/ac as the main plot, while seeding rates of 700,000, 900,000, and 1,100,000 seeds/ac served as subplots. The genotypes evaluated included Showdown and Butler's Gold. The timing of N application is assessed in two distinct phases, fall and spring. This design allows for a comprehensive analysis of how these factors interact and influence wheat yield and quality. These findings from this research would provide critical insights for optimizing agricultural practices.

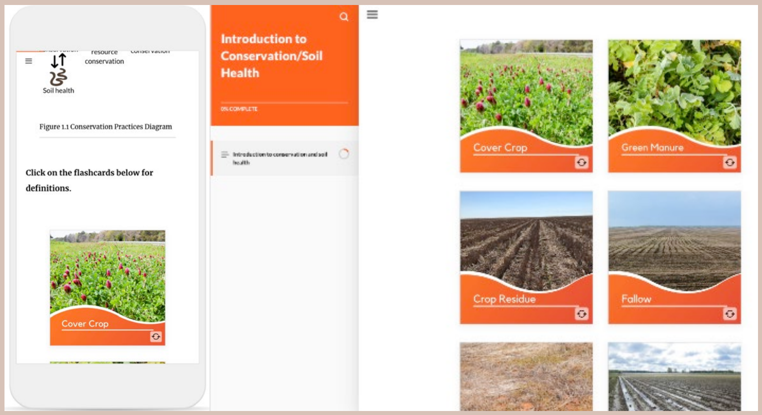
DEVELOPMENT AND USE OF ONLINE AGRONOMIC EXTENSION MODULES IN A CLASSROOM SETTING

Tori Booker

ABSTRACT

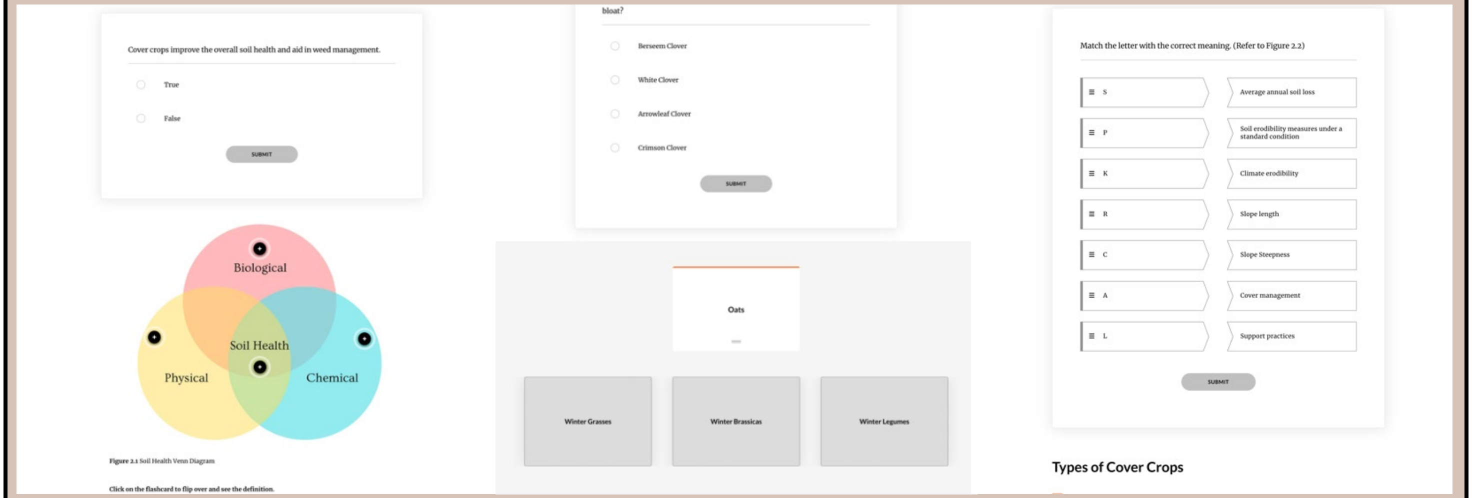
The implementation of online education modules has drastically increased in recent years. This has created the ability to provide learners with a well-rounded learning system that extends beyond watching a video or studying slides. This project consisted of learning modules that were developed for cover crop education. The modules were set in a reading and interactive format with short quizzes to reinforce the material. Three primary modules were developed and provided to undergraduate students to complete. Much of the feedback was positive concerning the learning objectives and the delivery methods used. Based on the feedback received, matching was a preferred method for a formative assessment. It was also found that learners would like more interactive, game-like activities to help re-enforce material upon completion. Overall, the online modules were effective in providing baseline material to a broad set of learners in an interactive manner.

Figure 1



We developed cover crop modules utilizing rise 360 which is a website-based software for creating online content. Once you complete your course in rise 360 it automatically formats the course for multiple devices. This means the instructor only must design the course once and it automatically reformats if the student is using a tablet, phone or laptop.

Figure 2



This cover crop course was emailed to an introductory agronomy course with 180 students. Of the 180, 142 students filled out a 9 question qualtrics survey to determine the ease of use and which learning activity was preferred if any. Figure 2 shows examples of the “knowledge checks” that the learners completed after reading the materials. There are traditional questions such as true false and multiple choice and have matching or drag and drop options.

Conclusion

The students rated the information given to them with a mean of 8.82 out of 10. 78% said the lessons were short, sweet, and to the point. 85% had no problem understanding the information. And 53% of the learners said that the sorting and matching games were their favorite. Overall, the students were highly receptive to the format so much so that they asked if the remainder of the semester would be setup this way. Rise 360 does take more time in developing the course material, but the added time has shown to be worth it. When creating these surveys and in any online capacity it is important to keep in mind the attention span of the learner and incorporate the interactive activities to keep the learner engaged. Lastly, having a concise learning goal is key, making sure you are putting the information in the course that you want to be highlighted in a clean format without extra materials will make learning in an online format successful.

This study is currently being continued using Q Method to understand students' perceptions on online learning.

EFFECT OF NITROGEN SOURCE, RATE AND TIMING ON FORAGE YIELD AND QUALITY IN BERMUDAGRASS PASTURE SYSTEMS

Nicholas Ssebalamu

ABSTRACT

The Oklahoma beef industry faces a significant decline in cattle population due to drought-driven forage shortages and increasing winter-feeding costs which account for over 50% of total costs in cow calf operations. While dormant bermudagrass provides limited winter forage, stockpiling and sod-seeding present potential strategies to extend the grazing season. However, the effectiveness of these approaches depends on effective nitrogen fertilization. This study evaluated the impact of nitrogen (N) source, rate, and application timing on forage yield and nutritional quality focusing on stockpiling and sod-seeded bermudagrass pasture systems. The research utilized three N sources (ammonium nitrate, urea, and urea + NBPT), four N rates (0, 44, 89, and 134 kg N ha^{-1}), and two application timings (single and split). Sixteen treatments in a split block design with three replications was established on existing bermudagrass pasture at three locations: Lindley Research and Demonstration Farm in Valliant, Cimarron Valley Research Station in Perkins, and the South-Central Research Station in Chickasha, Oklahoma from August 2024 to December 2024. Split-block and randomized complete block models were applied to evaluate the impact of the N treatments on the response variables using R software. At Valliant, N rate significantly affected forage yield, with 80 kg N ha^{-1} producing the optimal yield (3124 kg DM ha^{-1}), while more N beyond the optimal rate decreased yield by 24.4%. At Perkins, N source and timing interaction was the main driver of yield than rate, with urea + NBPT significantly outperforming untreated urea by 49% when applied as a single application while split application improved urea performance at higher rates. Sod-seeding produced forage with significantly higher crude protein (9.1% vs. 7.2%) and TDN (57.92% vs. 53.98%) compared to stockpiling. Nitrogen use efficiency decreased significantly with increasing N rates, with the highest efficiency (82.91% at Valliant and 63.73% at Perkins) observed at 44 kg N ha^{-1}. These results highlight the

importance of site-specific N management and demonstrate that sod-seeding cool-season annuals into bermudagrass can significantly improve forage nutritive quality for winter grazing while meeting nutritional requirements for dry cows and approaching adequacy for replacement heifers.

IDENTIFYING KNOWLEDGE GAPS IN HERBICIDE RESISTANCE RESEARCH: A COMPARISON BETWEEN OKLAHOMA AND OTHER U.S. STATES

Connor Cox

ABSTRACT

Herbicide-resistant grassy weeds in wheat and small grains are an escalating concern in Oklahoma. This study identifies knowledge gaps by comparing herbicide resistance research, reporting practices, and extension outreach programs in Oklahoma with those in the Pacific Northwest and Central Great Plains, two major U.S. wheat-growing regions. This review of published and unpublished literature, using both digital and state-level resources, focused on herbicide resistance trends and outreach efforts, revealing that many states employ herbicide screening programs and resistance maps to manage resistant weeds and guide management decisions. For Oklahoma farmers to effectively address herbicide resistance, implementing a state-specific screening program and developing resistance maps are essential. These tools will monitor resistant weed populations, identify emerging resistance patterns, and align with other states in tracking resistance trends. Although no direct causal relationship was found between outreach efforts and resistance management outcomes, expanding Oklahoma's extension services could reduce herbicide-resistant weed populations by improving awareness. Strategies such as using resistance maps, promoting integrated weed control, and enhancing communication will help farmers make more informed herbicide management decisions. Future research could explore how integrating herbicide screening and resistance maps can improve statewide resistance management.

CHEATING CHEATGRASS: UNDERSTANDING THE MORPHOLOGICAL CHARACTERISTICS OF *BROMUS* SPECIES

Itunuoluwa Adegbite, Brody Houser, Swati Shrestha, and Liberty Galvin

ABSTRACT

Brome grasses (Bromus spp.) have emerged as the most troublesome weeds in winter crop production systems throughout the United States, including Oklahoma. Different Bromus species have been identified in wheat fields across Oklahoma. However, accurate morphological characterization and identification of these species remain limited and fragmented, hindering effective management strategies. The research aimed to assess diversity for 25 different morphological traits (10 vegetative traits and 15 reproductive traits) among the Bromus species collected from wheat production fields across the 33 counties in the Oklahoma region and identify Bromus species based on taxonomic characteristics. The species were diverse for the traits studied, and a taxonomic comparison with USDA-GRIN reference samples revealed that all populations were variants of Bromus species. The identified Bromus species, Bromus catharticus, Bromus tectorum, and Bromus secalinus, were confirmed to be present in the field. Bromus catharticus exhibited rapid germination within four days, achieving an 88% germination rate. It was the tallest among the studied species, with an average height of 45 cm before maturity and 85 cm at full maturity. In contrast, Bromus tectorum displayed significantly delayed germination, taking 21 days with a lower germination rate of 38% and reaching a mean height of only 23 cm. Mean comparisons revealed no significant differences in height between Bromus catharticus from USDA sources and the field samples ($p>0.05$). Similarly, Bromus tectorum exhibited no significant variation between these sources. These findings highlight the substantial variation in growth dynamics among Bromus species, which may have implications for their ecological adaptation and competitiveness. This knowledge can facilitate accurate field identification and support improved management strategies for Bromus populations in agricultural systems.

B. catharticus - Rescue grass


B. secalinus – Rye brome


IMPACT OF PRE-EMERGENT RESIDUAL HERBICIDE ACTIVITY ON SOYBEAN SYSTEMS IN OKLAHOMA

Karina Beneton, Liberty Galvin, and Todd Baughman

ABSTRACT

As herbicide resistance becomes increasingly widespread across the United States, the use of preemergence (PRE) herbicides is considered a critical component of integrated weed management in soybean (*Glycine max* (L.) Merr.). This two-year study evaluated the residual weed control efficacy of four herbicide modes of action at Oklahoma State University research stations near Bixby and Fort Cobb, OK. Field trials were conducted in 2023 and 2024 using a randomized complete block design. Treatments included pyroxasulfone (89 g ai ha^{-1}), cloransulam-methyl (35 g ai ha^{-1}), sulfentrazone (89 g ai ha^{-1}), and metribuzin (420 g ai ha^{-1}), applied individually or in two-, three-, and four-way combinations. Preemergence applications were followed by a postemergence (POST) treatment of dicamba (1540 g ai ha^{-1}) + glyphosate (2100 g ai ha^{-1}) + s-metolachlor (1120 g ai ha^{-1}) + potassium carbonate (1400 g ai ha^{-1}). Palmer amaranth (*Amaranthus palmeri*) and large crabgrass (*Digitaria sanguinalis*) were the predominant weeds in these fields and are the focus of this presentation. Palmer amaranth control was at least 90% early season in Fort Cobb (2023), 88% in Bixby (2023) with all 3-way combinations. In 2024, at Fort Cobb at 4 WAPRE (weeks after PRE application), the control with pyroxasulfone + sulfentrazone + cloransulam-methyl reached 98%. In comparison, cloransulam-methyl alone had the lowest control at 60%. All-season long, control was at least 92% with all treatments. Large crabgrass control was at least 97.3% with pyroxasulfone + sulfentrazone in the early season in Fort Cobb (2024). Control was lower prior to POST applications at Bixby in 2023, but 99-100% with all treatments late season following POST application. In 2024, it was at least 93% season-long with all treatments applied. These findings emphasize the importance of using multiple modes of action to improve weed suppression, delay the development of resistance, and improve the overall effectiveness of herbicide programs in soybean systems. Additionally, the results suggest that environmental factors can pose challenges

to weed management strategies, and combining residual herbicides can help address some of these difficulties.

EVALUATING THE PREVALENCE OF HERBICIDE RESISTANCE IN ANNUAL ITALIAN RYEGRASS (LOLIUM *PERENNE L. SSP MULTIFLORUM*) WITHIN OKLAHOMA WHEAT FIELDS

Amna Dar, Liberty Galvin, and Swati Shrestha

ABSTRACT

Annual Italian Ryegrass (Lolium perenne ssp. multiflorum) is one of the most troublesome weeds in winter wheat production. The lack of new modes of action and overreliance on herbicides has led to suspected herbicide resistance, of which documentation is lacking in Oklahoma. To assess the distribution of resistant Italian ryegrass biotypes, a systematic statewide survey was conducted across 19 counties within active wheat fields in Oklahoma. In each field, seeds of 15-20 plants were collected and pooled. A total of 80 biotypes of Italian ryegrass were screened for resistance to quizalofop, imazamox, and glyphosate. The initial screening experiment was done in a complete randomized block design, with 2 replications in time. Herbicides were applied at twice the label-recommended rates for Imazamox (105g ai ha^{-1} or 12 fl oz per acre) and quizlalofop (123 g ai ha−1 or 24 fl ox per acre); and at the recommended rate for glyphosate (540 g ae ha−1 or 30 fl oz per acre). 21 days after treatment, Survivors were characterized as resistant (0% to 49% injury) or suspectable (<50% injury). Results revealed resistance to imazamox detected in 52% of samples tested, followed by 33% resistance to quizalofop and 10% resistance to Glyphosate. Cross-resistance to two or more herbicide modes of action was confirmed in 11 of the 19 counties surveyed, with a higher prevalence localized in the north-central Oklahoma.

HERBICIDE DOSAGE RESPONSES IN RESISTANT ANNUAL ITALIAN RYEGRASS (LOLIUM *PERENNE L. SSP MULTIFLORUM*) WITHIN OKLAHOMA WHEAT FIELDS

Amna Dar, Liberty Galvin, and Swati Shrestha

ABSTRACT

Annual Italian Ryegrass (Lolium perenne ssp. multiflorum) is one of the most troublesome weeds in winter wheat production. 19 counties in Oklahoma were surveyed for Italian Ryegrass and screened for herbicide resistance to quizalofop, imazamox, and glyphosate. Results revealed resistance to imazamox detected in 52% of samples tested, followed by 33% resistance to quizalofop and 10% resistance to Glyphosate. The resistance screenings were followed by dose-response assays of resistant Italian Ryegrass populations for each herbicide at 6 rates (0.5, 1, 2, 4, 8, and 16X), compared with a susceptible population at the same rates. The dose-response experiments were conducted in a completely randomized design with three replications. Dose-response assays revealed 78% of resistant biotypes showed little to no injury (<10%) up to 16x rate of quizlaofop, with the remaining 22% becoming susceptible at the 8x rate. In the imazamox dose response assay, 66.7% of resistant Italian ryegrass biotypes had showed full resistance up to the 16x rate, followed by 22% resistance up to 8x. 80% of glyphosate resistant biotypes showed little to no injury at 16X rate. These findings underscore the urgent need for diversified weed management strategies to prevent the further spread of multiple herbicide-resistant populations.

IMPACT OF PRE-EMERGENT RESIDUAL HERBICIDE ACTIVITY ON SOYBEAN SYSTEMS IN OKLAHOMA

Karina Beneton, Liberty Galvin, and Todd Baughman

ABSTRACT

As herbicide resistance becomes increasingly widespread across the United States, the use of preemergence (PRE) herbicides is considered a critical component of integrated weed management in soybean (*Glycine max* (L.) Merr.). This two-year study evaluated the residual weed control efficacy of four herbicide modes of action at Oklahoma State University research stations near Bixby and Fort Cobb, OK. Field trials were conducted in 2023 and 2024 using a randomized complete block design. Treatments included pyroxasulfone (89 g ai ha^{-1}), cloransulam-methyl (35 g ai ha^{-1}), sulfentrazone (89 g ai ha^{-1}), and metribuzin (420 g ai ha^{-1}), applied individually or in two-, three-, and four-way combinations. Preemergence applications were followed by a postemergence (POST) treatment of dicamba (1540 g ai ha^{-1}) + glyphosate (2100 g ai ha^{-1}) + s-metolachlor (1120 g ai ha^{-1}) + potassium carbonate (1400 g ai ha^{-1}). Palmer amaranth (*Amaranthus palmeri*) and large crabgrass (*Digitaria sanguinalis*) were the predominant weeds in these fields and are the focus of this presentation. Palmer amaranth control was at least 90% early season in Fort Cobb (2023), 88% in Bixby (2023) with all 3-way combinations. In 2024, at Fort Cobb at 4 WAPRE (weeks after PRE application), the control with pyroxasulfone + sulfentrazone + cloransulam-methyl reached 98%. In comparison, cloransulam-methyl alone had the lowest control at 60%. All-season long, control was at least 92% with all treatments. Large crabgrass control was at least 97.3% with pyroxasulfone + sulfentrazone in the early season in Fort Cobb (2024). Control was lower prior to POST applications at Bixby in 2023, but 99-100% with all treatments late season following POST application. In 2024, it was at least 93% season-long with all treatments applied. These findings emphasize the importance of using multiple modes of action to improve weed suppression, delay the development of resistance, and improve the overall effectiveness of herbicide programs in soybean systems. Additionally, the results suggest that environmental factors can pose challenges

to weed management strategies, and combining residual herbicides can help address some of these difficulties.

INFLUENCE OF RAINFALL TIMING ON THE EFFICACY OF PRE-HERBICIDES

Karina Beneton, Liberty Galvin, and Todd Baughman

ABSTRACT

The lack of new mode-of-action herbicides and increasing resistant weeds highlight the importance of pre-emergence (PRE) residual herbicide performance. Rainfall activation is crucial for efficacy. Field trials at Oklahoma State University research stations (Bixby and Lane, OK) assessed herbicide performance under different activation timings. Simulated rainfall (0.5”) was applied at 3, 7, and 14 days after PRE application (DAPRE). Treatments included flumioxazin (90 g ai ha^{-1}), pyroxasulfone (45 g ai ha^{-1}) alone and combined, and a three-way mix with metribuzin (420 g ai ha^{-1}). Weed control was visually assessed and analyzed using Tukey’s test (P = 0.05). At Lane, tall waterhemp (Amaranthus tuberculatus) control remained at least 97% for most treatments, except pyroxasulfone alone (89%) at 14 DAPRE. Pyroxasulfone also provided weaker control of ivyleaf morningglory (Ipomoea hederacea). Large crabgrass (Digitaria sanguinalis) control at 4 and 8 weeks after PRE (WAPRE) was highest (99%) with flumioxazin alone or in the three-way mix when activated at 3 DAPRE. Pyroxasulfone alone maintained at least 85% control of large crabgrass and ivyleaf morningglory when activated at 7 or 14 DAPRE. At Bixby, Palmer amaranth (Amaranthus palmeri) control at 6 WAPRE was 100% across treatments, regardless of activation timing. The three-way mix provided superior early-season control of Palmer amaranth (97%) when compared with flumioxazin or pyroxasulfone alone (82%). These results highlight the importance of activation timing and environmental factors in herbicide performance. Delayed activation can reduce residual control, but two- and three-way combinations, particularly the three-way mix, consistently improved long-term weed suppression

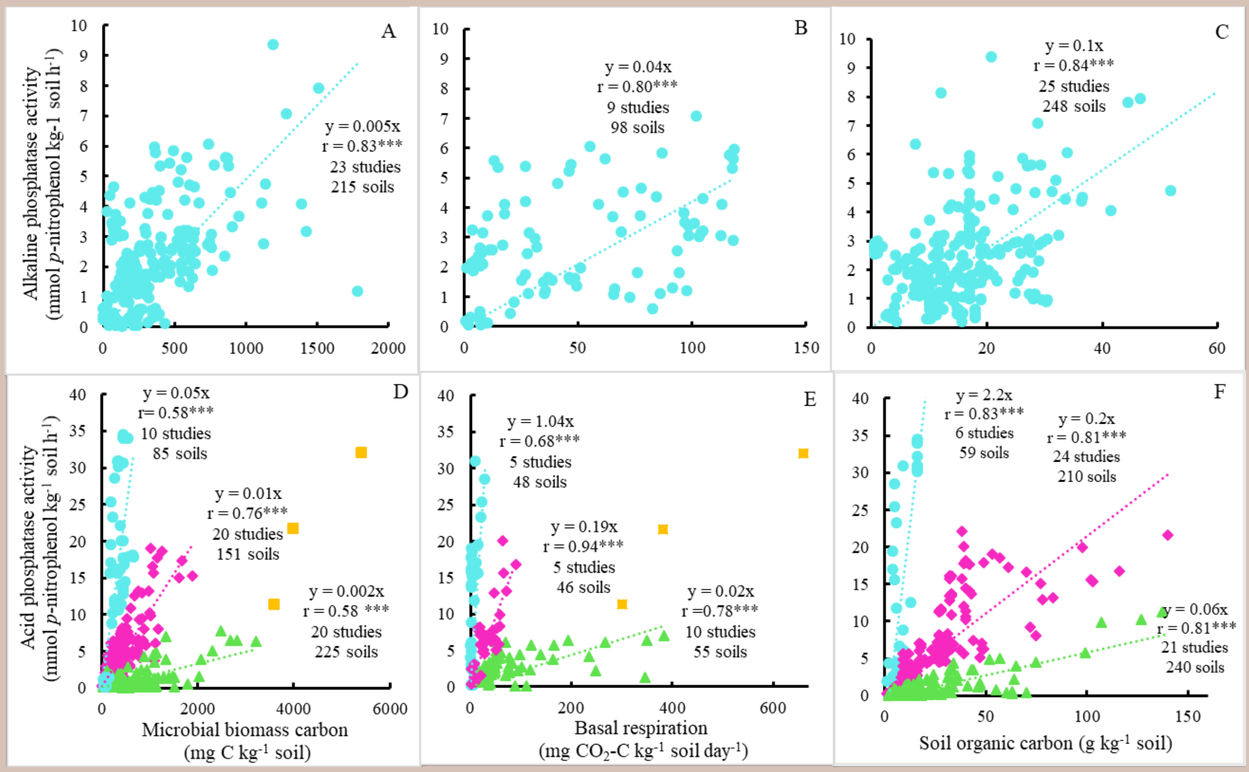
IDENTIFYING PREDOMINANT SOURCES OF PHOSPHOMONOESTERASES IN SOIL

Grace Williams and Shiping Deng

ABSTRACT

Phosphomonoesterases are a type of phosphatase that hydrolyze organic phosphate compounds into inorganic phosphate, making phosphorus available for plant uptake. Activities of these enzymes are intricately part of soil health as these activities play a crucial role in phosphorus nutrition and crop production. Based on analysis of data originated from over 100 studies encompassing 1,000 diverse soils, activities of acid phosphatase and alkaline phosphatase were both significantly positively correlated with microbial biomass carbon, respiration, and soil organic carbon content. However, these relationships differed between these two phosphatases, likely due to their intrinsic property variations resulting from varied source. It is recognized that alkaline phosphatases are plasma membrane-bound dimeric enzymes that share considerable commonality among themselves, but not acid phosphatases. Despite having a common functional identity, acid phosphomonoesterases differ widely regarding origin, molecular weight, amino acid homology, sequence length, and resistance to inhibitors and/or interaction with the environment. Further, evaluation of purified phosphatases from 40 studies and soil phosphatases from this study suggests that soil alkaline phosphatases are predominantly of bacterial origin, none of plant origin, while acid phosphatases come from diverse sources, including bacteria, fungi, plants and fauna.

Figure 1. The relationship between the activities of alkaline phosphomonoesterase (AKP) and acid phosphomonoesterase (ACP) with microbial biomass carbon (MBC), basal respiration, and soil organic carbon (SOC) content. Positive correlations were observed among the paired parameters. However, notable differences emerged between AKP and ACP in their relationships with microbial indicators and SOC. Unlike AKP, which showed no clear clustering, ACP exhibited three distinct clusters in its relationships with MBC, basal respiration, and SOC.



Conclusion

Soil alkaline phosphatases are predominantly of bacterial origin and not derived from plants, whereas acid phosphatases originate from diverse sources, including bacteria, fungi, plants, and fauna. This information can be integrated into soil management practices to enhance phosphatase activity, improving phosphorus availability and supporting crop production.

NUTRITIONAL STATUS AND BASIC SOIL PROPERTIES GOVERN MICROBIAL ABDUNANCE AND DIVERSITY

Grace Williams and Shiping Deng

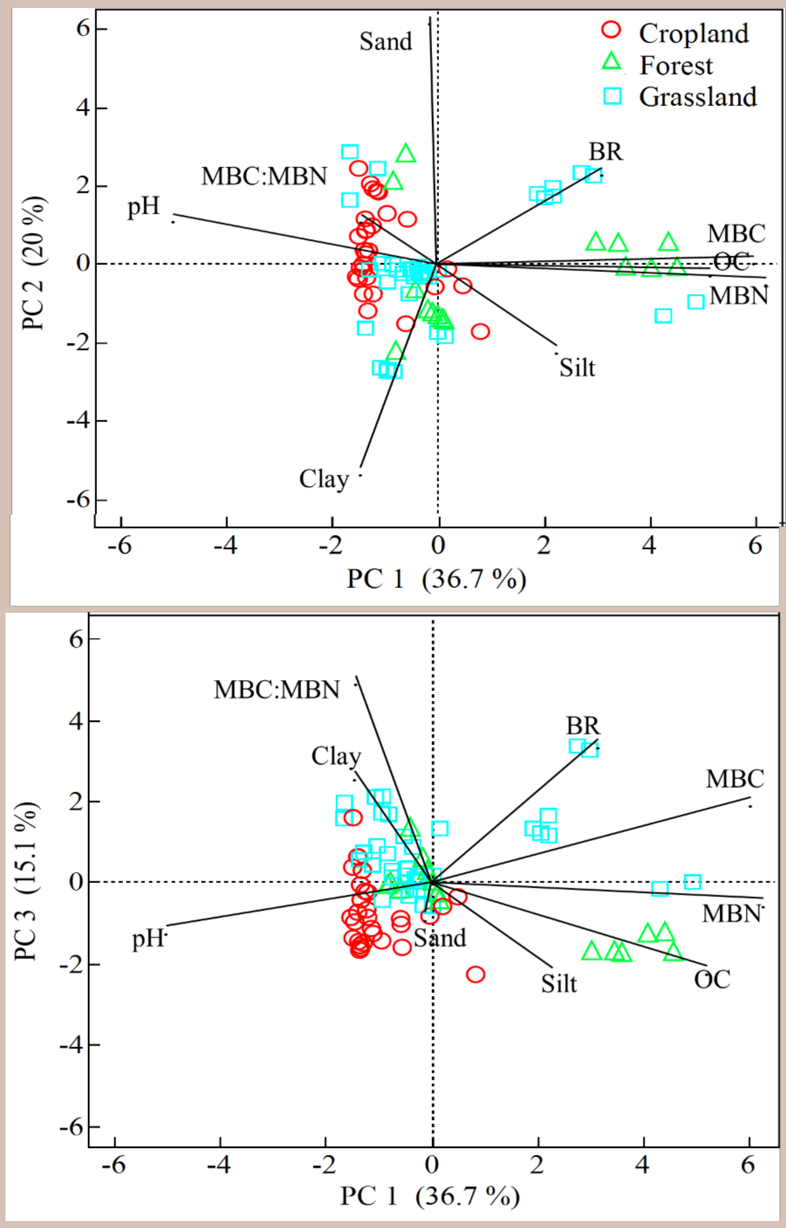
ABSTRACT

Soil properties significantly influence microbial activities, particularly organic carbon (OC) and pH. However, their relative importance remains uncertain. Based on data from 101 studies across five continents, soil organic carbon positively influences microbial abundance, as indicated by the content of microbial biomass carbon (MBC) and microbial biomass nitrogen (MBN), whereas the influence of soil pH is less clearly defined. Multivariate analysis revealed that soil OC predominantly drives microbial abundance, while soil pH negatively impacts it. Microbial community diversity and structure, as indicated by the MBC/MBN ratio, are closely linked to basal respiration. Additionally, clay content plays a crucial role in shaping microbial community diversity and structure, potentially by influencing oxygen availability, moisture retention, nutrient accessibility, and habitat protection. Soil pH directly impacts microbial diversity and composition by imposing physiological constraints on soil microorganisms and indirectly altering soil characteristics, such as nutrient availability. These findings suggest that soil texture and pH exert a predominant influence on community diversity, whereas OC content primarily governs microbial abundance by shaping soil nutritional status. This information could be utilized in agricultural management practices to enhancing soil fertility, foster microbial diversity by adjusting soil pH, guide irrigation and aeration practices to create favorable conditions for diverse microbial communities.

Table 1. Principal Components (PC1, PC2, PC3) loadings for Figure 1.

Parameter	PC1	PC2	PC3
Eigenvalues	3.3	1.8	1.4
Total variance (%)	36.7	20.0	15.1
Cumulative variance (%)	36.7	56.7	71.8
Microbial biomass carbon (MBC)	**0.90**	0.03	0.31
Microbial biomass nitrogen (MBN)	**0.94**	-0.05	-0.06
MBC:MBN ratio	-0.21	0.19	**0.76**
Basal respiration (BR)	0.47	0.37	**0.53**
Soil organic carbon (OC)	**0.78**	-0.02	-0.31
pH	**-0.75**	0.19	-0.16
Clay	-0.22	-0.78	**0.45**
Sand	-0.02	0.94	-0.11
Silt	0.34	-0.31	-0.32

Figure 1. Principal component (PC) biplot of soil properties, microbial biomass carbon (MBC), microbial biomass nitrogen (MBN), and the ratio MBC: MBN against the first three PCs. The length and direction of the vectors represent the magnitude and direction of the variable loadings.



Conclusion

Soil texture and pH exert a predominant influence on community diversity and community structure, whereas OC content primarily governs microbial abundance by shaping soil nutritional status. By acknowledging and managing these soil properties, agricultural and environmental practices can be optimized to promote robust microbial communities, leading to improved soil health and ecosystem sustainability.

CLIMATE REGIONS AS KEY DETERMINANTS OF MICROBIAL COMMUNITIES IN SOIL

Grace Williams and Shiping Deng

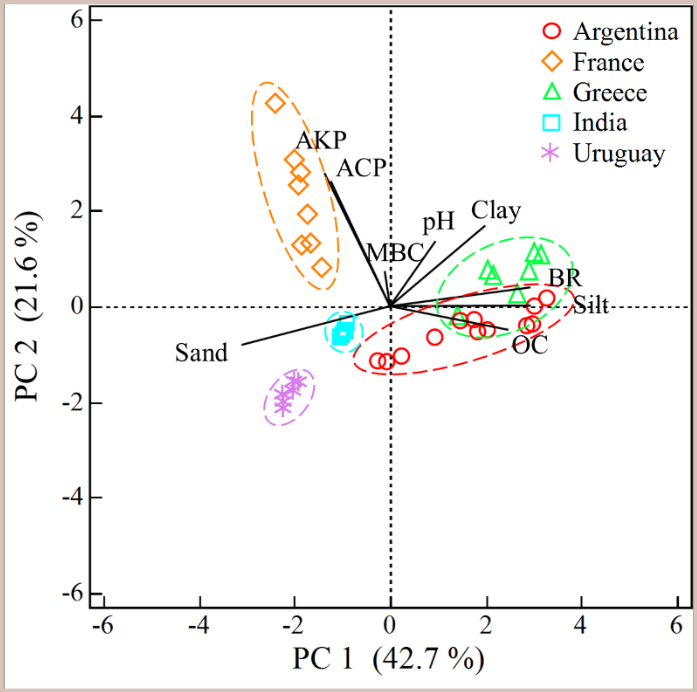
ABSTRACT

A meta-analysis of over 100 studies across multiple climate regions, encompassing 1,012 soils, was conducted to explore the relationships among factors governing soil ecosystem functions. The objective was to examine how climate region and land use type influence microbial abundance, activity, and composition. Climate regions were broadly classified based on annual mean temperature (°C) and annual cumulative precipitation (mm) as follows: tropical (≥18°C, ≥1,500 mm), dry (≥18°C, <500 mm), and temperate (10–22°C, 500–1,500 mm). Land use types were categorized as forest (primary, secondary, protected), grassland (pastures, fallow, rangelands), and cropland (no-till and traditional management practices). Although organic carbon (OC) content has long been recognized as a key factor influencing microbial communities, high OC levels alone did not necessarily correspond to high microbial biomass carbon (MBC). Instead, soils from tropical and temperate climates with significantly lower OC levels (7.8 g C kg^{-1} soil) exhibited higher MBC and an impressive 19-fold increase in microbial biomass per unit of OC compared to cold subalpine climate soils, which had substantially higher OC levels (126.7 g C kg^{-1} soil). This finding highlights that warmer climates favor microbial growth, leading to greater microbial carbon use efficiency. While numerous individual studies have emphasized the importance of land use, this meta-analysis revealed that climate region exerted a predominant influence on the relationships between microbial communities and the soil environment.

Table 1. Summary of properties and indicators of the 1012 soils used in the study.

Property or Indicator	Range	Mean
pH	3.4 — 9.7	6.8
Organic carbon (g kg^{-1})	1.2 — 126.7	16.2
Total nitrogen (g kg^{-1})	0.03 — 290.2	1.4
Total phosphorus (g kg^{-1})	0.20 — 1420	0.40
Total potassium (g kg^{-1})	0.1 — 1833	2.10
Sand (g kg^{-1})	300 — 894	747
Silt (g kg^{-1})	280— 750	515
Clay (g kg^{-1})	80 — 800	440
MBC (mg C kg^{-1} soil)	14.5 — 6529	539
MBN (mg N kg^{-1} soil)	2.1 — 1170	73.5
Basal respiration (mg CO_2–C kg^{-1} soil day^{-1})	0.8 — 384.2	44.5

Figure 1. Principal component (PC) biplot displaying soil properties, microbial biomass carbon (MBC), basal respiration, and the activities of alkaline phosphatase (AKP) and acid phosphatase (ACP) against the first two PCs. The length and direction of the vectors represent the magnitude and direction of the variable loadings. Data clustered by geological location and climate region but not land use or soil types.



Conclusion

While the importance of land use was widely reported, data from this study revealed climate region as the predominant factor influencing the interplay between microbial communities and the soil environment. Warmer climates promote microbial growth, leading to greater microbial carbon use efficiency.

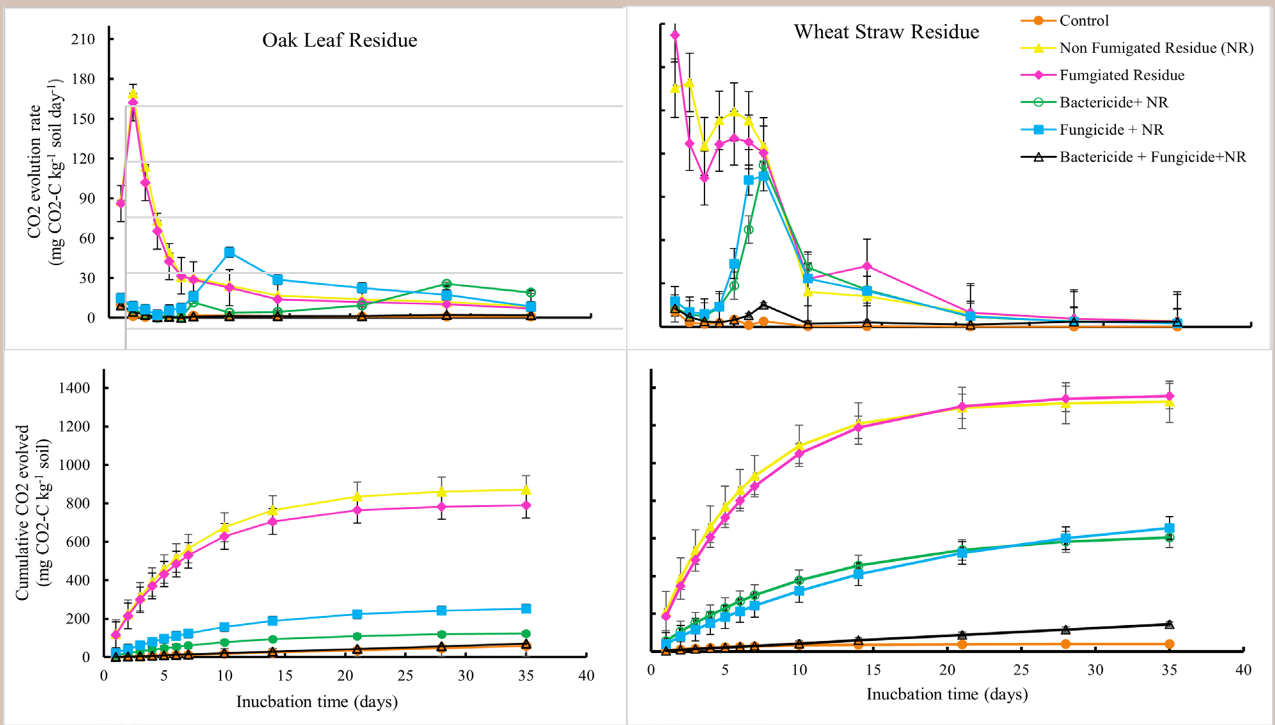
ROLE OF PLANT RESIDUES IN SHAPING SOIL MICROBIAL ACTIVITY AND DIVERSITY

Grace Williams, Casey Hentges, and Shiping Deng

ABSTRACT

Soil organic carbon influences microbial activity and diversity, with the extent and nature of these changes depending on the carbon source and type. Urbanization may significantly impact these dynamics. Understanding how oak leaves—a common organic material used in home gardens—and wheat straw—a major U.S. crop—affect microbial communities could inform management strategies that enhance ecosystem health, function, and sustainability. A laboratory incubation study examined the effects of different carbon sources on soil microbial activity and diversity, as well as the relative contributions of bacteria and fungi to carbon residue decomposition. Soils were amended with sterilized and non-sterilized plant residues from oak leaves and wheat straw, with or without bactericide, fungicide, or both. Carbon dioxide (CO_2) evolution was monitored over time during incubation. In the short term, plant residues significantly altered soil microbial community diversity and structure. Carbon availability was a limiting factor for microbial growth. Bacteria surpassed fungi in decomposing the complex carbon compounds in oak leaf amendments, whereas both bacteria and fungi contributed to the rapid decomposition of the more labile carbon in wheat straw. Oak leaf residues fostered moderate microbial activity through the breakdown of complex carbon compounds, while wheat straw induced rapid and sustained microbial activity due to its higher cellulose content. Despite equal carbon amendments, wheat straw residues promoted greater microbial activity than oak leaf residues, as evidenced by higher cumulative CO_2 evolution. The slower decomposition rates observed in oak leaves may be attributed to their higher lignin content.

Figure 1. Soil CO_2 evolution rate and cumulative CO_2 evolved in fumigated and non-fumigated oak leaf or wheat straw residues (8 g C kg^{-1} soil), with or without bactericide, fungicide or both treatments (2 mg g^{-1} soil).



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Conclusion

Bioavailable carbon is a critical factor influencing microbial growth. During a 35-day incubation period, bacteria contributed more to plant residue decomposition than fungi. Wheat straw promoted greater microbial growth and faster residue degradation compared to oak leaves.

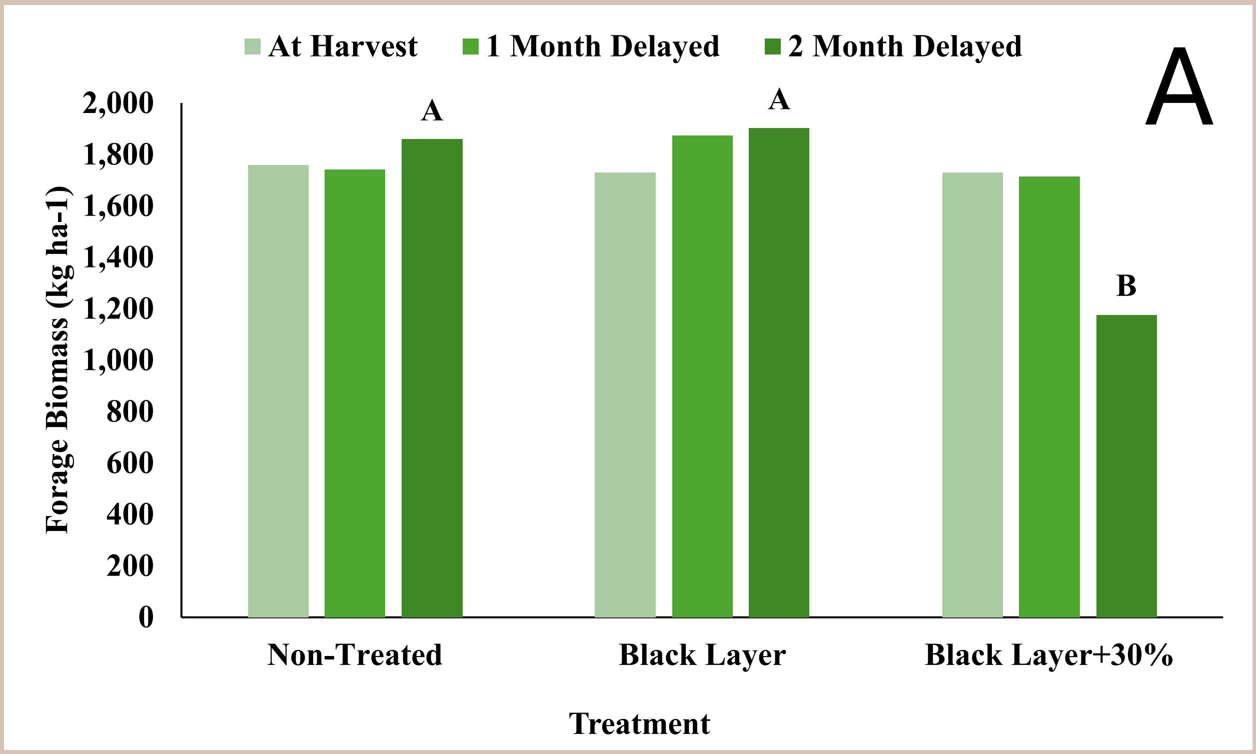
IMPACT OF MANAGEMENT ON FORAGE QUALITY AND NITRATE TOXICITY OF GRAIN SORGHUM RESIDUE FOLLOWING HARVEST

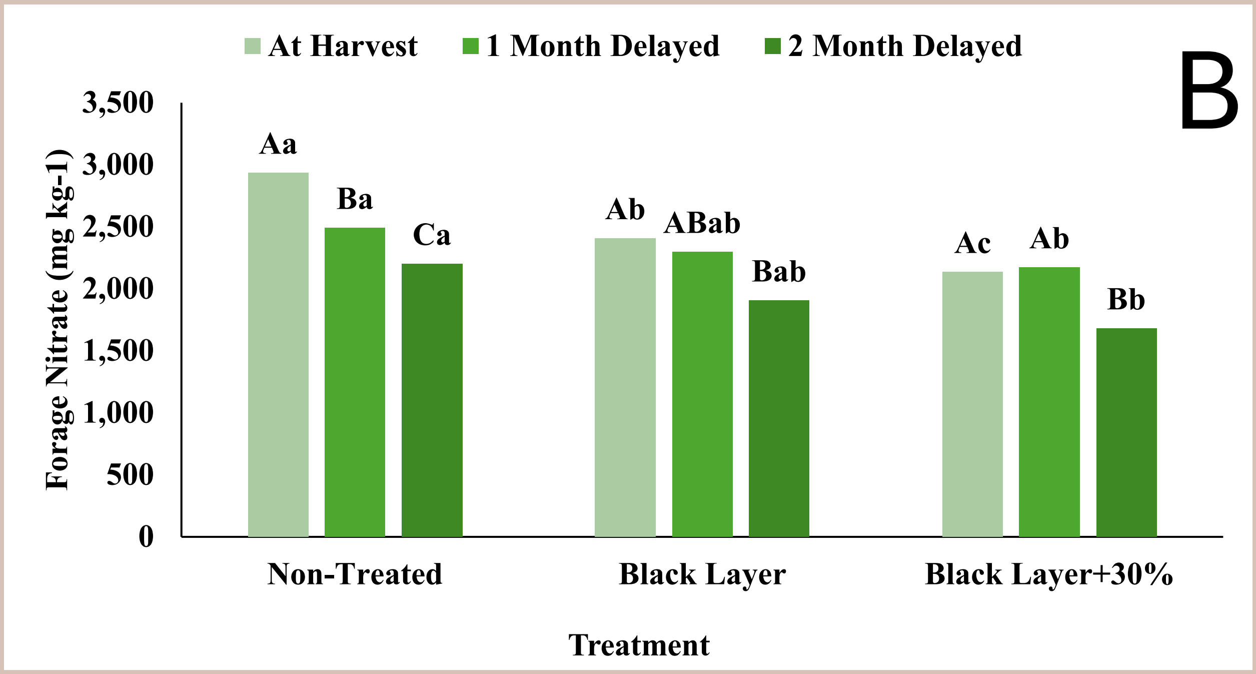
Josie Rice, Josh Lofton, Tori Booker, and Stephen Harris

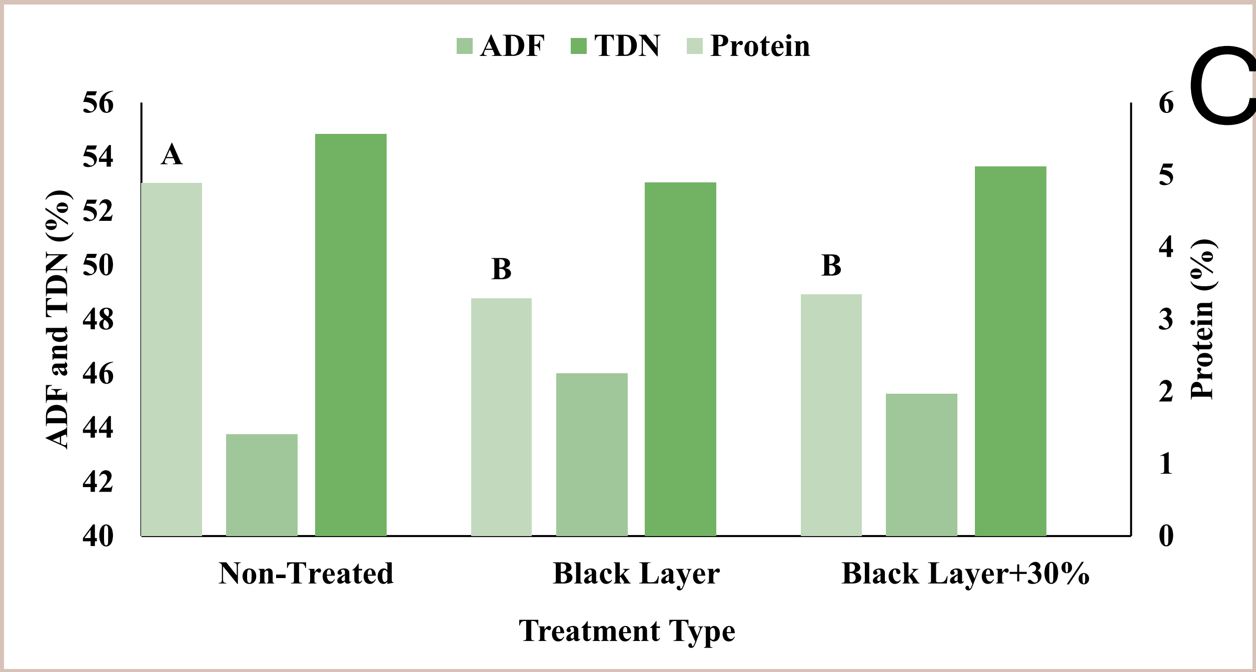
ABSTRACT

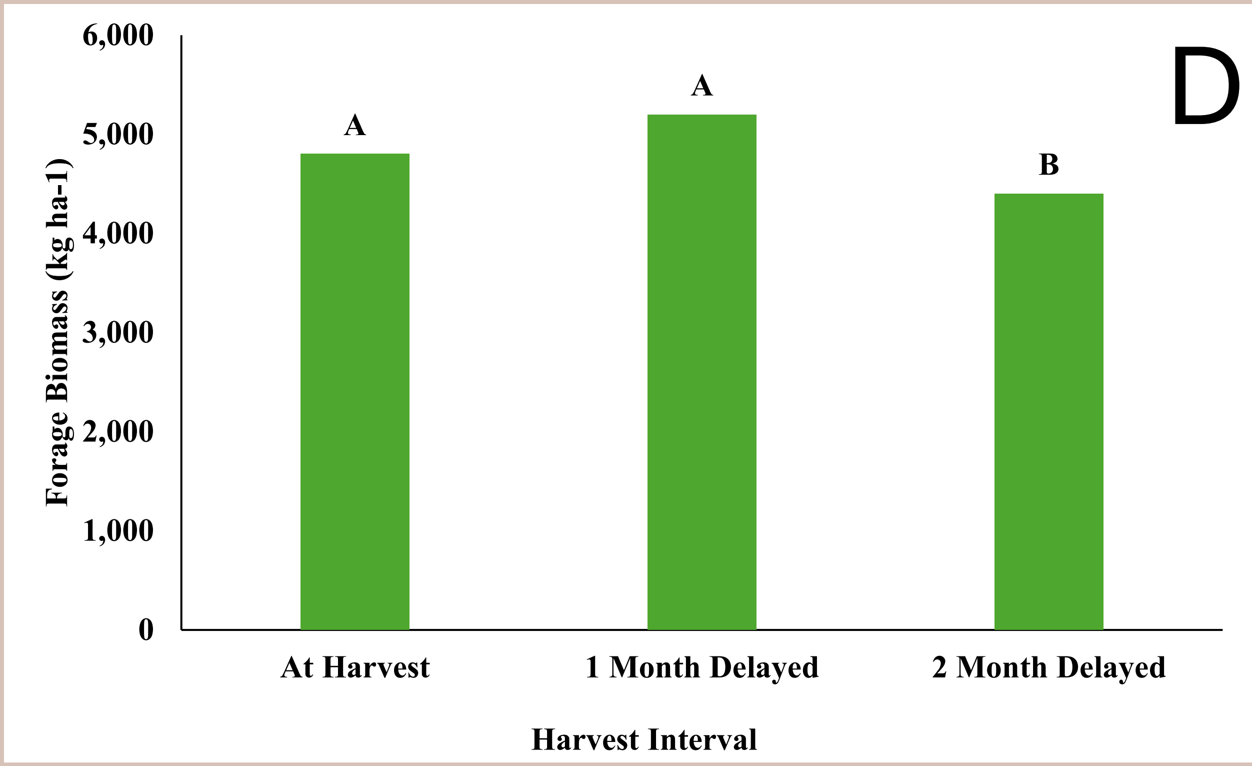
Oklahoma producers have been looking for ways to minimize risk and expand on economic opportunities. Grain sorghum is a valued summer crop selection in the Southern Great Plains due to high heat tolerance and good rotational options within various cropping systems. While grazing residue has always been a practice in Oklahoma, interest in grazing grain sorghum residue has increased in recent years, especially in areas with limited forage availability. However, nitrate content (NO3-) within the stover can cause issues for grazing animals due to nitrate toxicity. A randomized complete block design with four replications was conducted at the Mingo Valley Research Station near Bixby, OK in 2022 and at the Cimarron Valley Research Station near Perkins, OK in 2023. The purpose of this study was to evaluate forage quality (biomass, protein, ADF, and TDN) and nitrate content (NO3-) accumulation within the sorghum residue following harvest. Three treatments were utilized: non-treated, a harvest aid of glyphosate at black-layer, and a harvest aid of glyphosate at black-layer +30% (30% grain moisture). Three timing treatments were also utilized: biomass samples were taken at harvest, 1-month post-harvest, and 2-months post-harvest. Grain sorghum residue may not fully meet the nutritional needs for animals even though it is a very viable feed option in terms of cost effectiveness. However, it can offer fiber and some protein to contribute to the nutritional needs of grazing animals. Supplementation may be a required aspect when grazing sorghum residue but can vary from year to year. Adequate sampling should still be conducted for nitrates as the risk for nitrate toxicity is still present. With proper management strategies and optional supplementation, grain sorghum residue is considered a valuable alternative grazing or feeding source in the southern Great Plains.

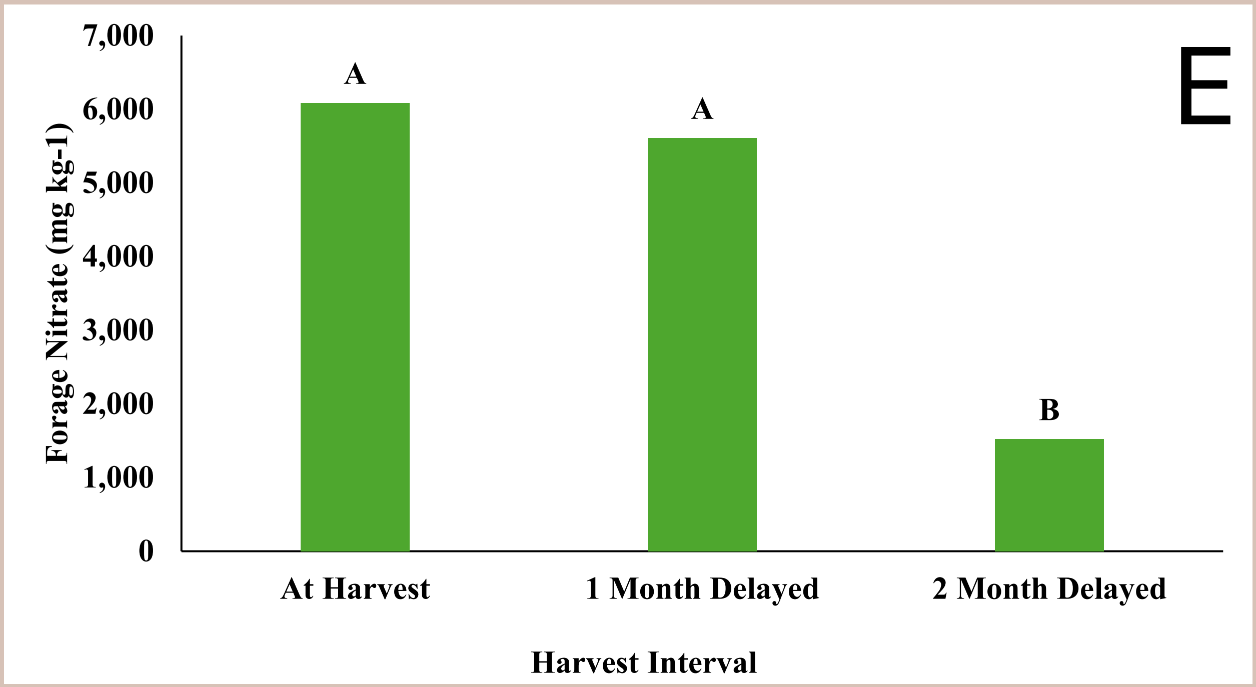
Figures: Sorghum biomass as well as forage nitrate and quality parameters for Bixby 2022 (A-C) and Perkins 2023 (D-F).

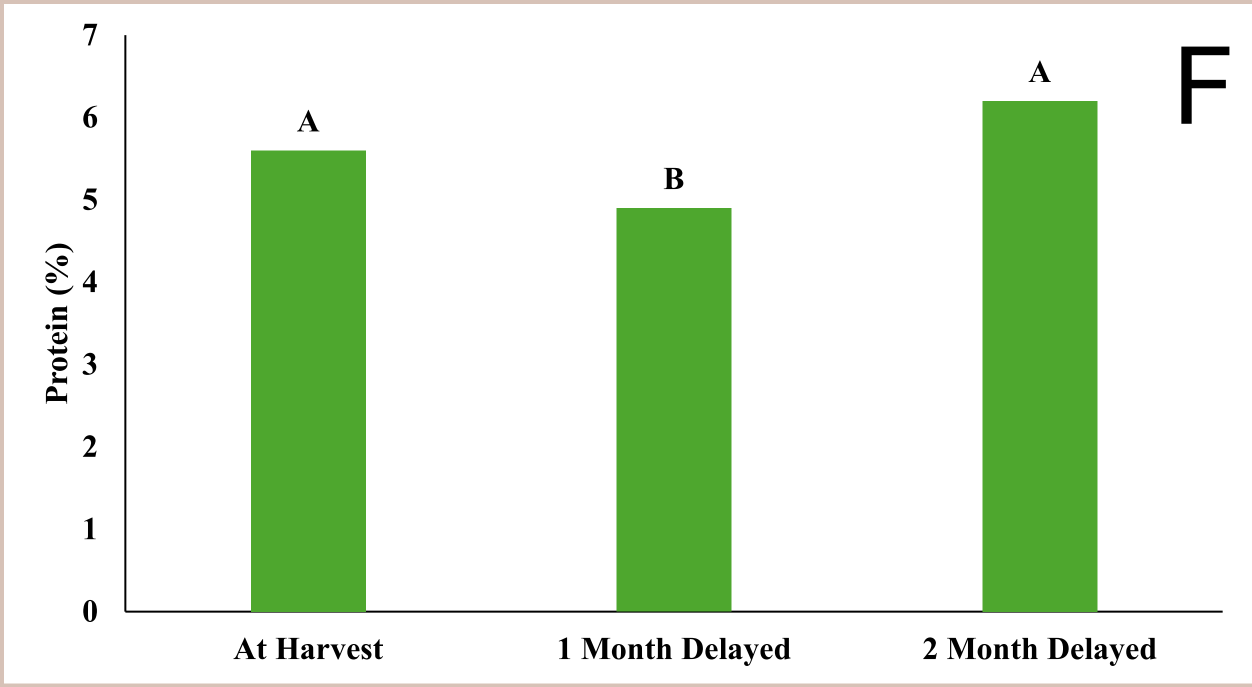





ADF
TDN
Protein
C
A
B
B
ADF and TDN (%)
56
54
52
50
48
46
44
42
40
Protein (%)
6
5
4
3
2
1
0
Non-Treated
Black Layer
Black Layer+30%
Treatment Type


D
A
A
B
Forage Biomass (kg ha-1)
6,000
5,000
4,000
3,000
2,000
1,000
0
At Harvest
1 Month Delayed
2 Month Delayed
Harvest Interval


E
Forage Nitrate (mg kg-1)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
A
A
B
At Harvest
1 Month Delayed
2 Month Delayed
Harvest Interval


F
Protein (%)
7
6
5
4
3
2
1
0
A
B
A
At Harvest
1 Month Delayed
2 Month Delayed

Conclusion

Utilizing grain sorghum residue for grazing in Oklahoma is a promising option, particularly for animals with lower nutritional requirements with supplementation. The application of desiccants did not significantly impact key parameters, but the impact of harvest timing is intriguing. Grain sorghum residue offers a compelling choice for post-harvest grazing in the Southern Great Plains, filling the seasonal forage gap, and supporting livestock nutrition and agricultural sustainability.

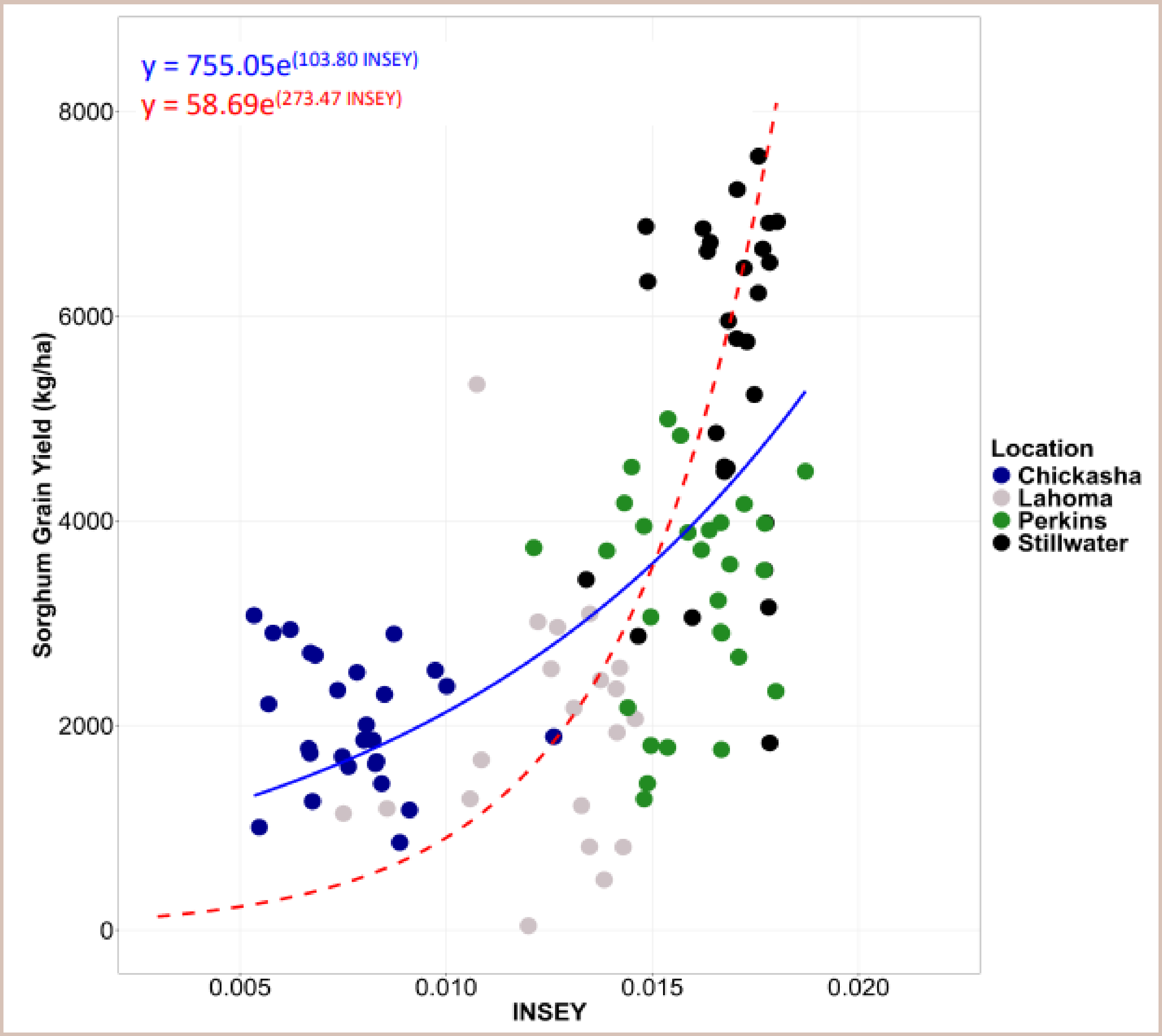
EVALUATING EXISTING CALIBRATION CURVES FOR SENSOR BASED IN-SEASON NITROGEN MANAGEMENT IN GRAIN SORGHUM

Deepa Pokharel and Steve Phillips

ABSTRACT

Oklahoma ranks among the top seven states for grain sorghum production, harvesting approximately 381 million kilograms annually. With increasing sorghum acreage, precision in nitrogen (N) fertilizer recommendations is critical to maximizing yield and minimizing environmental impact. The current sensor-based nitrogen rate calculator (SBNRC) used in Oklahoma is based on data from the late 2000s and may not reflect recent agronomic advances or changing production conditions. Thus, this study aims to evaluate the accuracy of the existing calibration curves used in the SBNRC and to validate their effectiveness under present-day production systems. Field trials were conducted during the 2023 growing season across four Oklahoma locations: Lahoma, Chickasha, Perkins, and Stillwater. A randomized complete block design was employed, with six replications at Chickasha and Perkins and four at Lahoma and Stillwater. Nitrogen was applied at rates of 0, 45, 90, 135, and 180 kg/ha at Lahoma, and 0, 34, 67, 101, 135, 168, and 202 kg/ha at the other three sites. GreenSeeker optical sensors were used to collect Normalized Difference Vegetation Index (NDVI) data at the mid-vegetative growth stage. The resulting INSEY (in-season estimated yield) values were analyzed to assess the relationship between sensor readings and grain yield. Preliminary results suggest that, except for Chickasha, data from the other locations generally align with the reference SBNRC model. However, further multi-location and multi-season studies are needed to refine the calibration curves and enhance the predictive accuracy of sensor-based nitrogen recommendations for Oklahoma sorghum producers.

Figure: Relationship between INSEY and sorghum grain yield. Colors indicate the locations. The dashed orange line is the reference model used to predict yield potential, while solid blue line represents the finding from current study to predict yield potential.



MAXIMIZING LAND USE AND PRODUCTIVITY IN OKLAHOMA: A COMPARISON OF REGULAR, INTERCROPPED, AND DOUBLE CROP SYSTEMS

Josie Rice, Josh Lofton, Stephen Harris, and Matthew Drendel

ABSTRACT

Crop intensification and increased diversity has been suggested in recent years to improve sustainability and reduce risk within cropping systems. Modified Relay Intercropping has recently gained traction for many Oklahoma producers as they are looking to capture more of the growing season to create better use efficiency within their production systems, thus creating an intensified cropping system. A randomized complete block design with four replications was conducted at the Mingo Valley Research Station near Bixby, OK and the Lake Carl Blackwell research plots near Stillwater, OK. The goal of this study was to compare crop yields in a modified relay intercropping system as well as a regular and double crop system. Within the modified relay system, soybeans were hand-planted into actively growing hard red winter wheat 45 days prior to wheat harvest. Even though regular season systems create a simplified management approach, you are more vulnerable to diseases and pests. Double-cropped systems create efficient land use within the system but lack in terms of timing windows and the risk of yield reduction. The modified relay intercropping system has numerous advantages such as maximizing land productivity and the utilization of resources; however, many challenges are presented within this production system such as creating the appropriate harvest logistics and maintaining the management strategies as they can become quite complex. Each system can offer producers advantages and disadvantages, albeit modified relay intercropping stands as a viable option for Oklahoma producers.

Table: Pod and node counts for soybean relative to regular, intercrop, and double crop systems. OK Corral and Smiths Gold correlate with wheat varieties used at Bixby. Smiths Gold was the only variety utilized at Lake Carl Blackwell.

OK Corral- Bixby

System	Mainstem Nodes	0 Bean Pod	1 Bean Pod	2 Bean Pod	3 Bean Pod	4 Bean Pod
Regular	17.2	4.3	0.3	5.9	26.3	1.2
Intercrop	17.7	6.4	0.4	6.2	26.4	1.3
Double-Crop	14.3	0.7	0.9	7.7	25.8	0.9

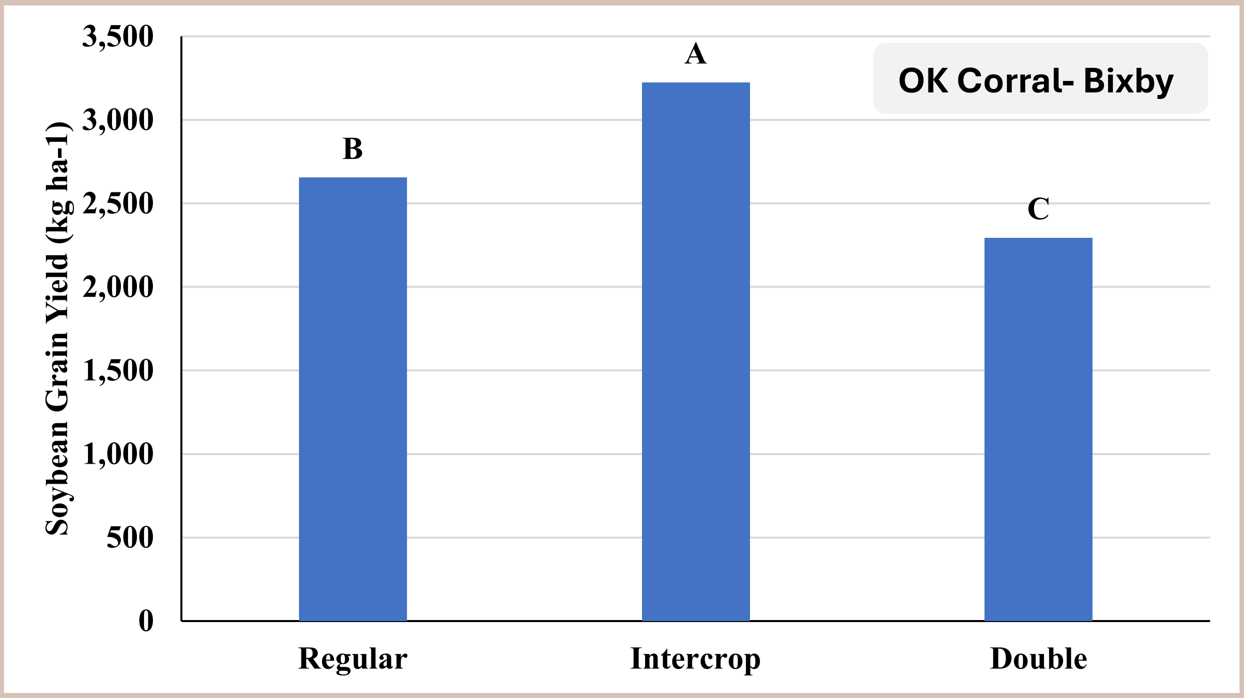
Smithsgold- Bixby

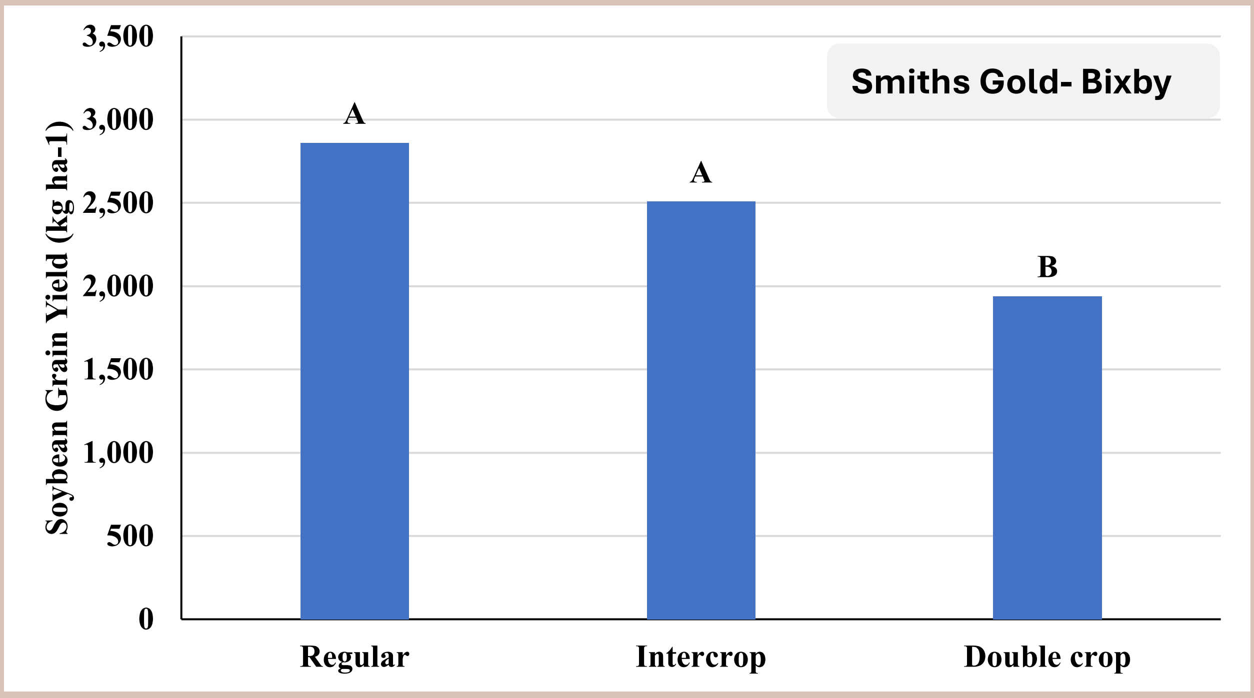
System	Mainstem Nodes	0 Bean Pod	1 Bean Pod	2 Bean Pod	3 Bean Pod	4 Bean Pod
Regular	19.5	8.2	0.7	8.9	44.3	1.1
Intercrop	18.0	7.6	0.7	8.1	32.9	0.8
Double-Crop	17.1	2.6	0.6	6.7	24.3	1.1

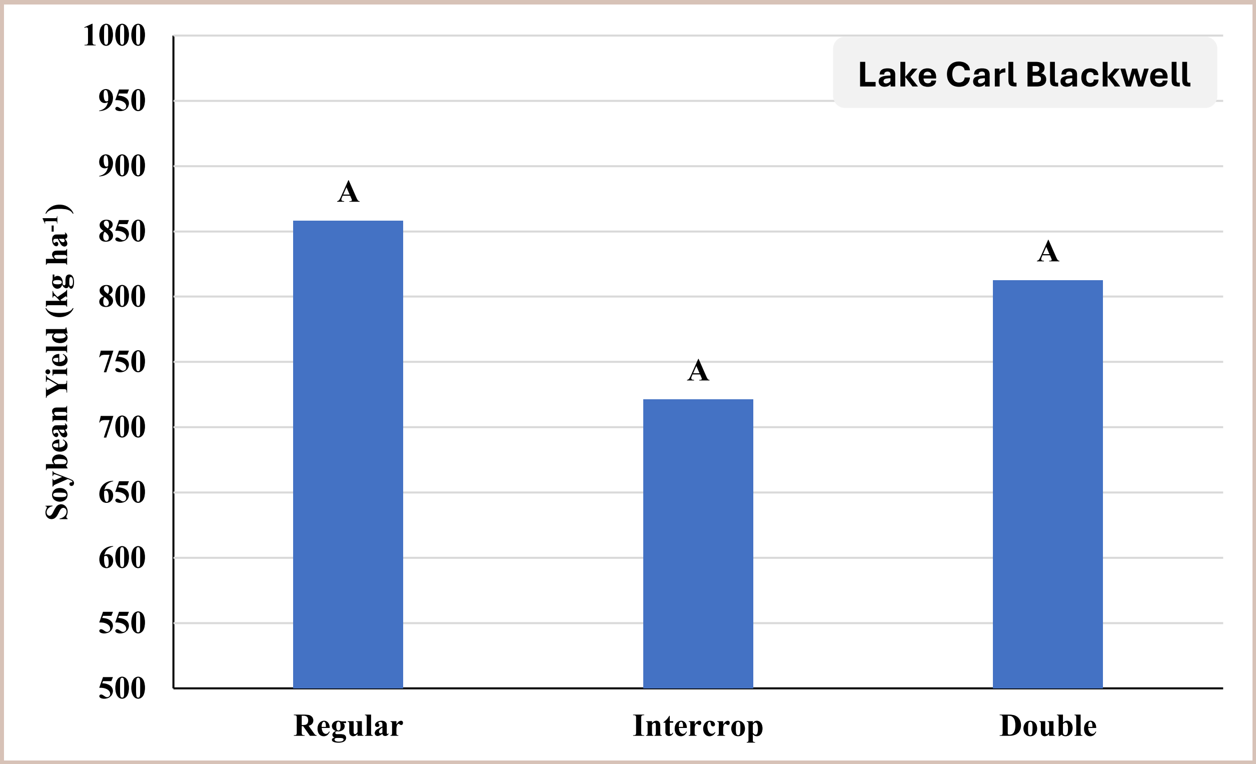
Lake Carl Blackwell

System	Mainstem Nodes	0 Bean Pod	1 Bean Pod	2 Bean Pod	3 Bean Pod	4 Bean Pod
Regular	15.3	4.7	1.7	3.8	4.7	0.1
Intercrop	17.5	8.1	1.9	5.7	9.6	0.2
Double-Crop	13.1	3.3	1.3	6.6	7.3	0.2

Figures: Soybean grain yield relative to regular, intercrop, and double crop systems. OK Corral and Smiths Gold correlate with wheat varieties used at Bixby. Smiths Gold was the only variety utilized at Lake Carl Blackwell.







Conclusion

Oklahoma producers may explore intercropping as a viable option; however, regular season or double-crop soybeans generally offer a safer and more reliable choice. These conventional approaches align more consistently with the region's climate and cropping patterns, mitigating risks associated with intercropping complexities and potential yield variations.

EFFECT OF SHORT-TERM CROP ROTATION ON SPATIAL AND TEMPORAL VARABILITY OF SOIL HEALTH INDICATORS AND THEIR RELATIONSHIP WITH CROP YIELD

Ella Hazel B. Estrada

ABSTRACT

Soil health is the ability of the soil to function to function and provide ecosystem services. Healthy soil should support sufficient food and fiber production for human needs while maintaining ecosystem services vital for human life quality and biodiversity conservation. USDA-NRCS defines soil health as "The continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans". The terminology and understanding of soil health is evolving, prompting research into various influencing factors, including cropping systems such as crop rotation and as well as its spatial and temporal variability. There is limited research in short-term studies on how spatially and temporally varied soil health indicators interact and collectively impact crop yield. In this study, the influence of short-term crop rotation and the spatial and temporal variability on soil health indicators will be evaluated and compared with crop yield to see if there is a relationship between these factors. The study will be conducted at the Oklahoma State University Lake Carl Blackwell Agronomy Research Station in Stillwater, Oklahoma, in a complete randomized split-plot design with crop rotation as the main plot factor and with split treatment of two rates of nitrogen fertilizer application (70 and 140 lb N/Acre). Surface soil samples (6-in from the surface) will be collected five times (mid-summer 2024, following fall harvest (November 2024), mid-winter 2025, before planting in spring 2025, and mid-summer 2025) for various chemical, physical, and biological properties of the soil. Physical (soil texture, available water capacity, penetration resistance, and wet aggregate stability), chemical (soil pH, electrical conductivity, and extractable P, K, Fe, Mn, Zn, and total N and C), and biological properties (soil protein index, soil respiration, and active carbon) will be analyzed and used for soil health scoring. The Comprehensive Assessment of Soil Health (CASH) scoring systems, as modified by Fine et al. (2017), will be used for scoring the different indicators. The scores will then be spatially and temporally analyzed to see if there will be

a significant variability within the field, and then will be compared to crop yield to determine if there is a relationship between soil health scores that may varies spatially and temporally and crop yield.

RELATIONSHIP OF DEPTH OF ROOT-RESTRICTIVE LAYER IN SOIL WITH SPATIAL VARIABILITY IN CROP YIELD AND SURFACE HEALTH INDICATORS

Ishneet Kaur and Steve Phillips

ABSTRACT

Every soil possesses its own profile characteristics which are a consequence of its genesis. Various geological and pedological factors interact during soil genesis and form soil profiles with different characteristics, which sometimes result in the formation of layers not conducive to plant root penetration and reduce crop yield. Soil health is also significantly affected by inherent properties of soil, and it is important to understand potential limitations posed by soils due to inherent profile characteristics. The study examines the impact of depth of root-restrictive layer on spatial variability of crop yield and the effect of presence of such layer in soil profile on surface soil health. Understanding this relationship is crucial for adopting adequate sustainable farming practices. Morphological characterization of deep core profile samples (1m depth) is done to identify potential root-restrictive layers and yield data is used to construct correlation between the two factors. Surface soil samples from 6-inch depth are analyzed for health indicators like aggregate stability, soil respiration, pH, electrical conductivity, total N, total C, Extractable P, K, Na, Mg, Fe, Mn, Zn and their correlation with crop yield is calculated using multiple regression analysis. This relationship helps us to better understand intrinsic limitations posed by soils to crop production and soil health and devise corresponding optimizations.

IMPACT OF PLANTING DATE AND NITROGEN RATE ON OAT FORAGE BIOMASS QUALITY

Josie Rice, Tori Booker, Josh Lofton, and Stephen Harris

ABSTRACT

This study investigates the effects of planting dates and nitrogen (N) application rates on the growth, yield, and forage quality of oats (Avena sativa L.) at EFAW near Stillwater, OK. Field experiments were conducted using four distinct planting dates and two nitrogen application rates (0 and 56 kg ha-1) to evaluate their impact on oat forage performance. The experimental design was a randomized complete block design with four replications. Key variables measured were biomass accumulation, canopy cover (Canopeo), and normalized difference vegetation index (NDVI). Results indicated significant interactions between planting dates and N rates. Early planting generally resulted in higher biomass compared to later planting dates. The application of 56 kg ha-1 improved biomass production and forage productivity across all planting dates, with the most pronounced effects observed in the later planting dates. Additionally, the 56 kg ha-1 rate significantly enhanced forage quality, characterized by increased crude protein content and improved digestibility. Canopy cover and NDVI readings were unaffected by planting date and N rate. These findings provide valuable insights for optimizing oat production through appropriate scheduling of planting and nitrogen application to maximize both yield and forage quality.

Figure 1: Impact of N rate and planting date on spring planted oat forage biomass collected at booting. Different letters indicate significant differences in biomass.

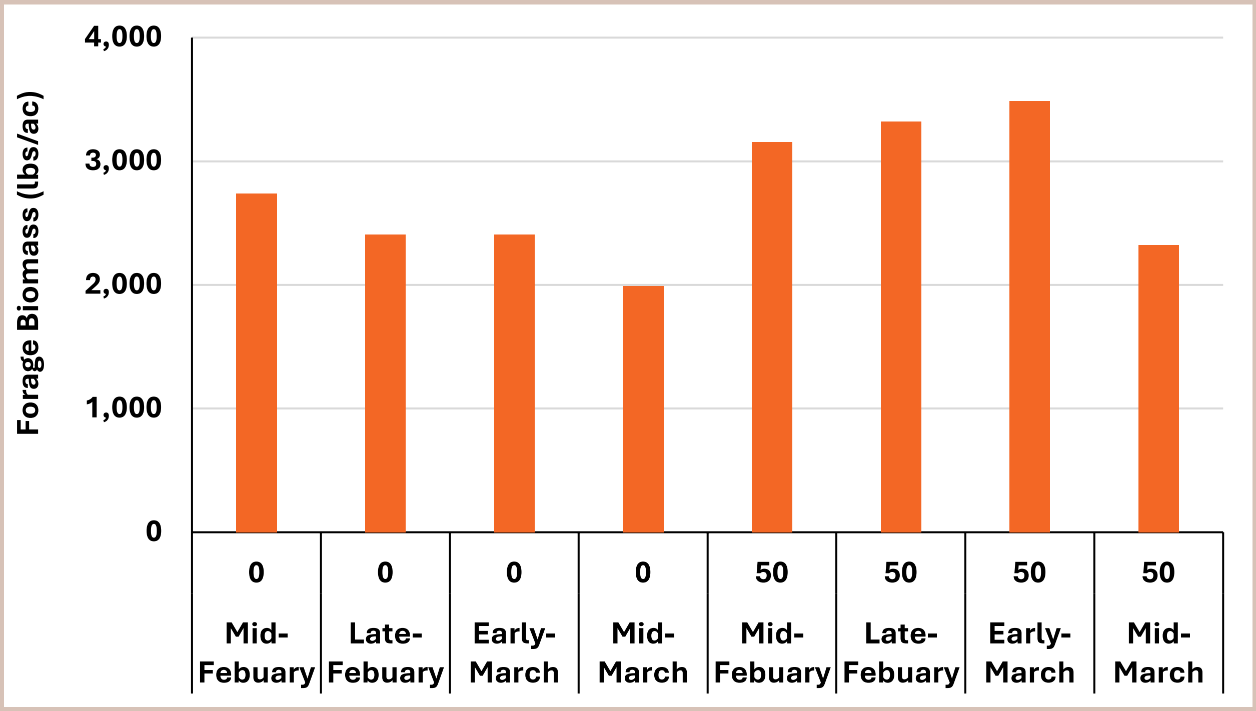
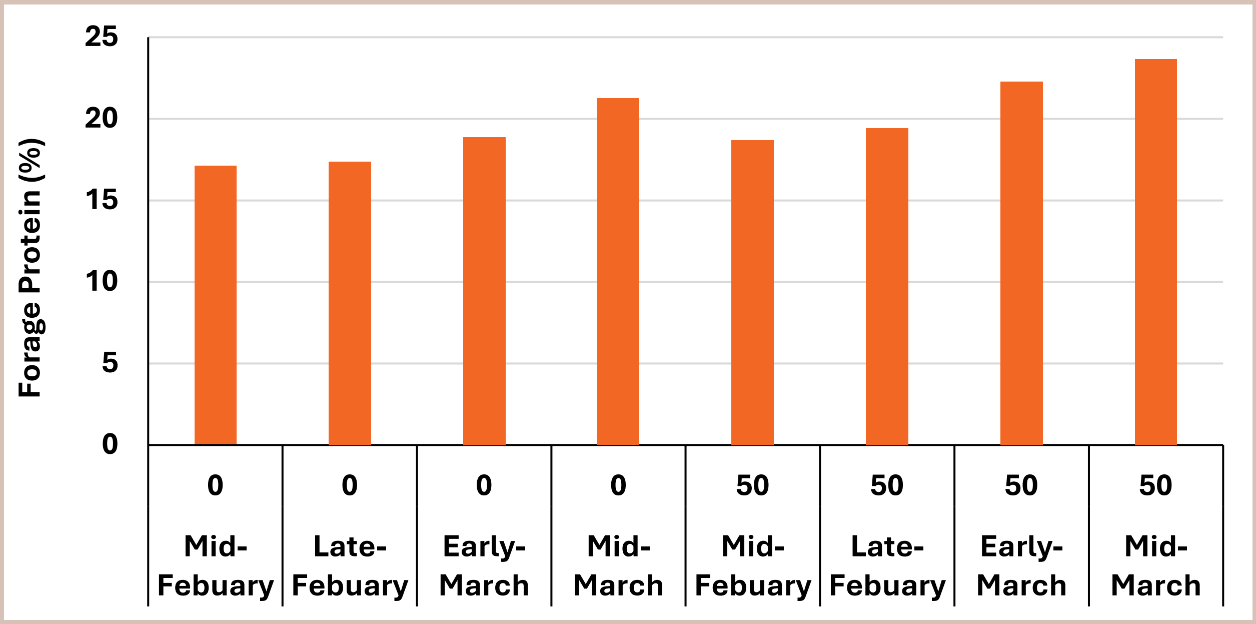


Figure 2: Impact of N rate and planting date on spring planted oat forage protein content. Different letters indicate significant differences in protein.



Conclusion

Overall, planting in mid-to late-February combined with 50 lbs/ac of N maximizes forage biomass yield for oats. Delayed planting reduces biomass yield, but a N application can partially compensate for the loss. Nitrogen also improves forage protein content, making early planting with N the most effective strategy for Oklahoma spring-planted oat production.

SOIL STRUCTURAL QUALITY IN CULTIVATED AND UNCULTIVATED LANDS IN THE US SOUTHERN GREAT PLAINS

D. Cole Diggins, Madison L. Morris, and Tyson E. Ochsner

ABSTRACT

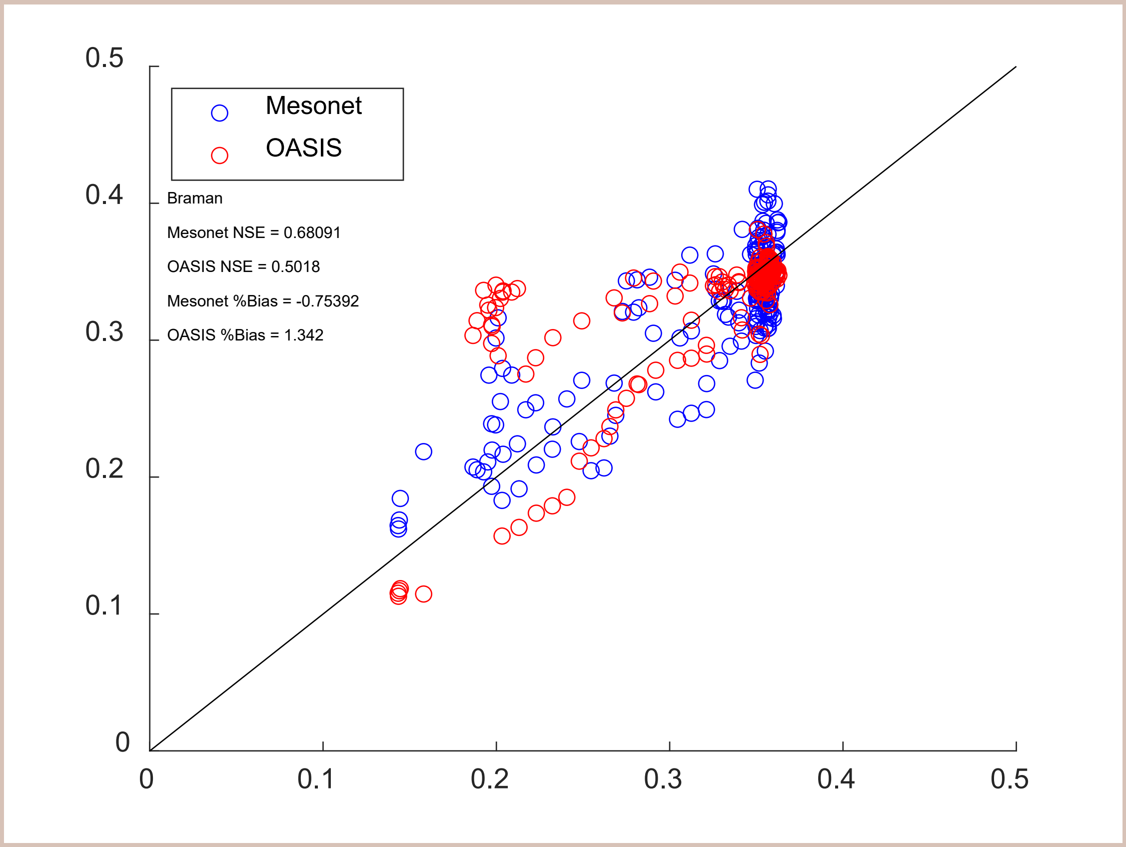
Soil structural quality is one important indicator of soil health and can be degraded through long-term cultivation. The objective of this study was to determine the differences in structural quality between cultivated and uncultivated soils in the US Southern Great Plains region. At six study locations across Oklahoma and Kansas transects spanning adjacent cultivated and uncultivated soils were selected. Soil structural quality was assessed in the field using the Visual Evaluation of Soil Structure (VESS) method at six sampling sites separated by 20 m in both the cultivated and uncultivated portions of the transect. We also collected 5-cm diameter soil cores at two depths at each sampling site to assess the soil's physical and chemical properties in the laboratory. At all six study locations, the cultivated sites had significantly lower soil structural quality, as indicated by their higher VESS scores, than their uncultivated counterparts. Clay content positively correlated with higher VESS scores and lower structural quality, likely due to higher bulk density and lack of friability in soils with higher clay content. Soils with lower water contents also had higher VESS sores and lower structural quality. Further analysis regarding differences between the properties of cultivated and uncultivated soils are ongoing, with emphasis on hydraulic conductivity, soil texture, water retention, and chemical properties.

AN EVALUATION OF THE OKLAHOMA STATE SOIL MOISTURE MAP WHEN ESTIMATING THE SOIL MOISTURE OF ACTIVE SYSTEMS

D. Cole Diggins and Tyson E. Ochsner

ABSTRACT

Soil moisture is an important indicator of potential crop yield, and knowledge of the soil moisture conditions can have an impact on agricultural management practices. State and federal networks provide publicly accessible data on various environmental variables including soil moisture. However, these stations are typically located in grassland, and thus their soil moisture conditions differ from adjacent cropping systems. To evaluate the extent of these differences, soil moisture data were collected in various cropland sites across Oklahoma, USA using cosmic ray neutron sensing. These data were compared to the soil moisture measurements from the nearest station of the Oklahoma Mesonet and to estimates from the Oklahoma Automated Soil Information System (OASIS), which accounts for spatial variability in soil texture and precipitation. The OASIS system provided better soil moisture estimates for these cropland sites than did the data from the nearest Mesonet station, but both showed limited accuracy with mean absolute differences of 0.09 cm3 cm-3 for the Mesonet and 0.5 cm3 cm-3 for the OASIS model. Nash-Sutcliffe efficiencies were -1.38 for the Mesonet and -0.57 for the OASIS model when compared to the soil moisture.


Mesonet
OASIS
Braman
Mesonet NSE = 0.68091
OASIS NSE = 0.5018
Mesonet %Bias = -0.75392
OASIS %Bias = 1.342
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5

CRONOS: AN EVALUATION OF CROPLAND MONITORING STATIONS DURING THE 2020-2021 WINTER WHEAT CROPPING SEASON

D. Cole Diggins and Tyson E. Ochsner

ABSTRACT

In croplands the conditions within the soil-plant-atmosphere continuum can differ substantially from those at the closest available weather station, thus there is a need for monitoring stations optimized for deployment in cropland. Developed in response to this need, CRopland Observatory NOdeS (CRONOS) are portable in-situ, multi-sensor monitoring stations designed to monitor soil water content, green canopy cover (GCC), and atmospheric conditions. The objective of this study was to evaluate the performance of first-generation CRONOS systems on working farms. During the 2020-2021 winter wheat (Triticum aestivum) growing season, CRONOS stations were installed at three sites across Oklahoma, USA. Each station was equipped with a cosmic-ray neutron sensor to measure soil moisture, a camera to monitor GCC, and an all-in-one weather station. The soil moisture estimates were validated by comparison with distance- and depth-weighted average volumetric water content determined by soil sampling. The station's GCC estimates were compared with the average GCC at the field scale. Meteorological data from the all-in-one weather stations were compared with observations from the Oklahoma Mesonet closest to each CRONOS site. The CRONOS stations accurately determined field-average soil water content, with a mean average difference (MAD) of 0.022 cm3cm-3 and a Nash-Sutcliffe Efficiency (NSE) of 0.756. The CRONOS GCC estimates showed greater discrepancies from the field-scale averages than did the soil water content estimates, with a MAD of approximately 12% and NSE of 0.43. For atmospheric conditions, the level of agreement between the CRONOS stations and the nearest Mesonet station varied, with NSE values ≥ 0.89 for measurements of air temperature, solar radiation, and atmospheric pressure but lower NSE values ranging from 0.34 – 0.87 for precipitation, relative humidity, and wind speed. Sensors were reliable ≥ 98.4% percent of the time except for the cameras, for which 43.6% of the scheduled photos were missing or invalid.


Huk

ENHANCING SOL MOISTURE MONITORING IN OKLAHOMA: SENSOR SELECTION AND OPTIMAL INSTALLATION DEPTH FOR THE HYDRONET

Tyson E. Ochsner, Erik S. Krueger, Gabriela Yuri Inaba Da Silva, and Ali Ashrafi

ABSTRACT

A key goal of the Oklahoma Hydronet is to improve soil moisture measurements across Oklahoma by installing advanced soil moisture sensors at approximately 120 existing Oklahoma Mesonet sites. We have conducted two lines of research to support these new installations: sensor selection and depth of installation. These sensors will provide scientists, farmers, land managers, and the public with real-time data accessible via web dashboards (oklahomahydronet.org). These enhanced soil moisture monitoring systems will better support agricultural practices and environmental management across Oklahoma.

Soil moisture sensor selection

We evaluated the accuracy of three sensor models—METER Group TEROS 12, Acclima TDR 310, and Acclima TDR 315, as well as the Campbell Scientific 229 (CS 229) sensor currently used by the Mesonet, by comparing sensor-based measurements with those made using neutron based soil moisture sensor. Results showed that all candidate sensors surpassed the CS 229 in accuracy, with the TEROS 12 performing best across multiple statistical metrics. Consequently, the TEROS 12 has been chosen to enhance soil moisture monitoring.

Soil moisture sensor installation depth

Soil moisture is currently measured by Oklahoma Mesonet at depths of 5, 25, 60, and 75 cm, but to our knowledge, these depths were chosen without the support of quantitative analyses. Therefore, we conducted field and modeling analyses to determine which sensor placement depths would most accurately quantify 1 meter soil water storage. Using soil moisture profiles from 34 field samples and 6576 profiles generated by the HYDRUS-1D model, we calculated 1 meter soil water storage and compared this against storage estimated using information from only four soil sensor depths. We found that a sensor depth combination of 10, 30, 60, and 90 cm was among the most accurate combinations,

while offering the added benefit of familiarity for many users (4 inches, and 1, 2, and 3 feet). Field installations of TEROS 12 sensors at these depths are ongoing.

IMPACT OF COTTON HARVEST AIDS ON DIFFERENT COVER CROPS

Harsanjam Singh, Sumit Sharma, Josh Lofton, and Alex Rocateli

ABSTRACT

In Center High Plains, cotton harvest timing leaves inadequate time for establishing covers due to cold and dry conditions. Planting covers in standing cotton could be an option, however impact of harvest aids on covers is not known. This study evaluates the response of cover crops (winter pea, triticale, hairy vetch, black oats, crimson clover, and brassica) to different cotton harvest aids (DFT-6EC, AIM). The crops were grown in pots in climate-controlled chambers and green cover was measured weekly using Canopeo® application. The crops were sprayed 6 weeks after planting and green cover was observed until week 10. The green cover was reduced in all crops by at least 50% within two weeks after spray, with winter pea losing 100% of green cover. These results show that cover crops can be inter-seeded in cotton crops, provided the covers have at least 6 weeks for growth before harvest aid applications.

Figure

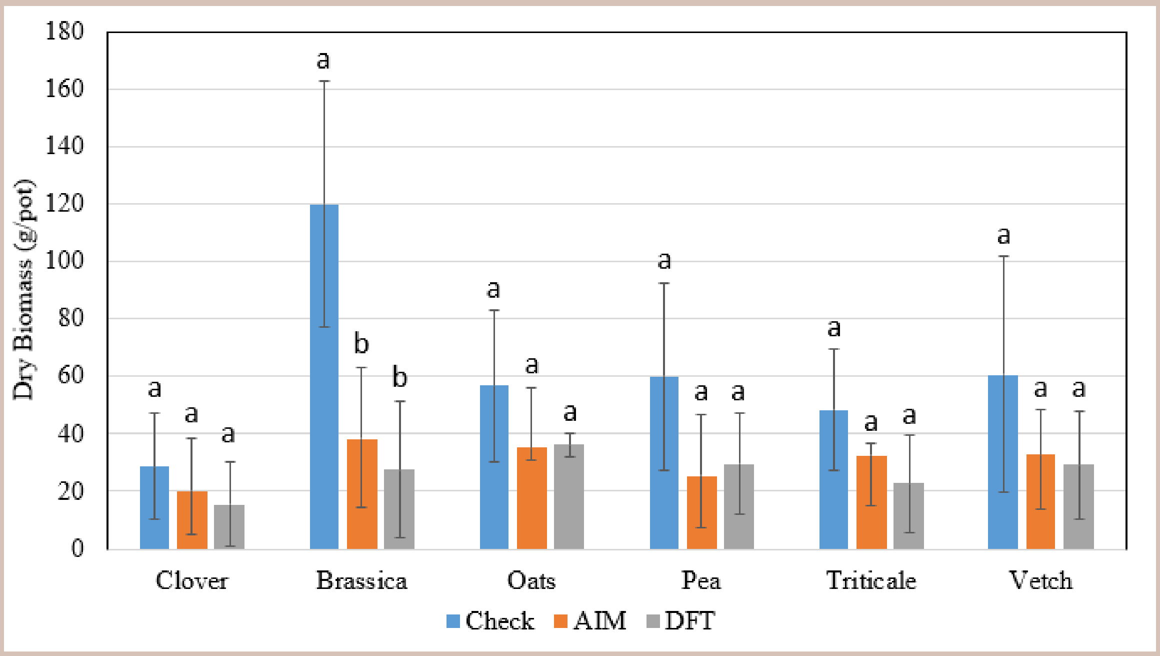


Figure 1: Biomass production data in (a) Check (b) AIM (c) DFT at the termination of replications 10 weeks after planting.

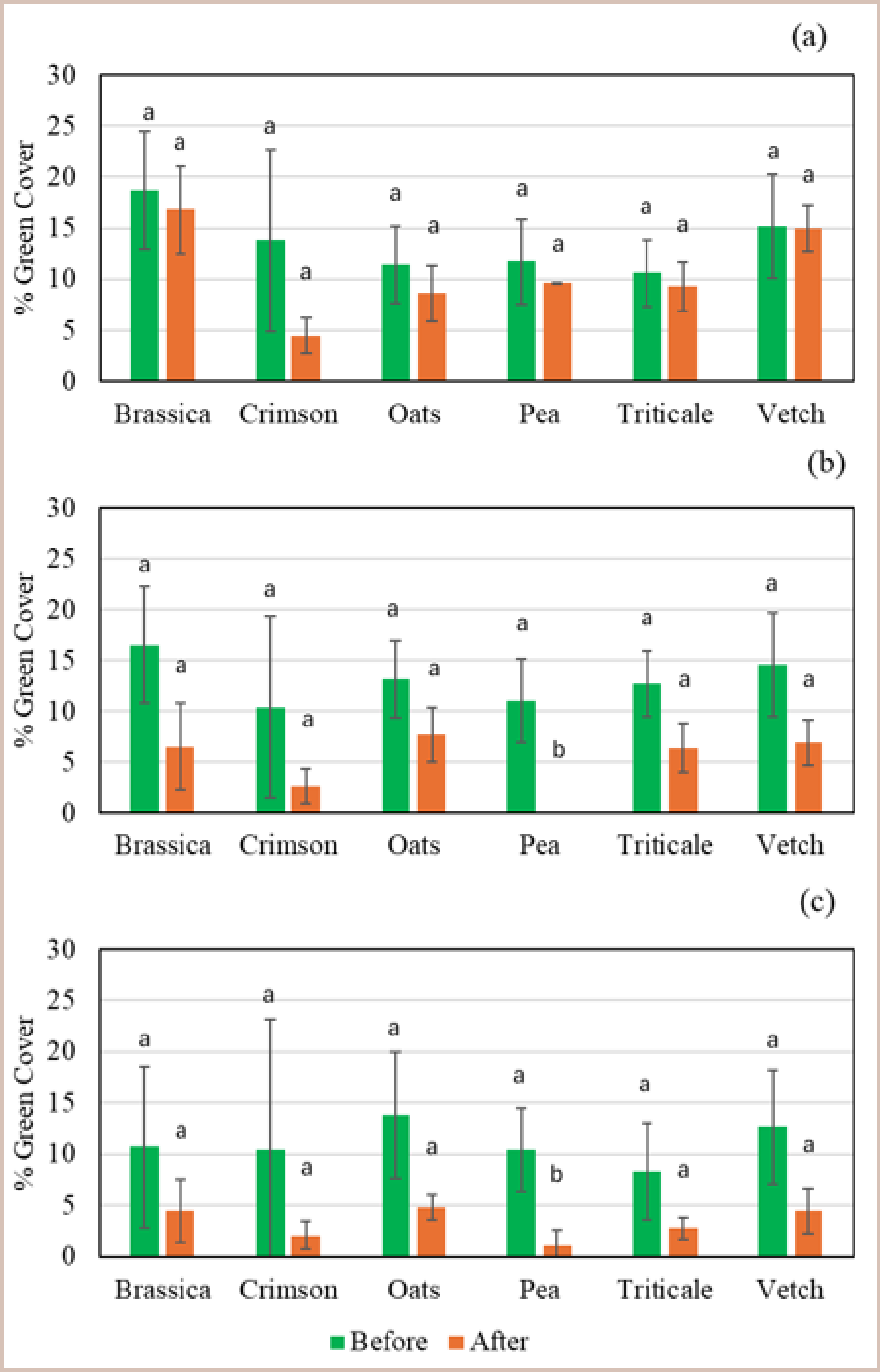


Figure 2: Green cover reduction in (a) check (b) AIM (c) DFT cotton harvest aids from just before spray (green) to two weeks after spray (orange).

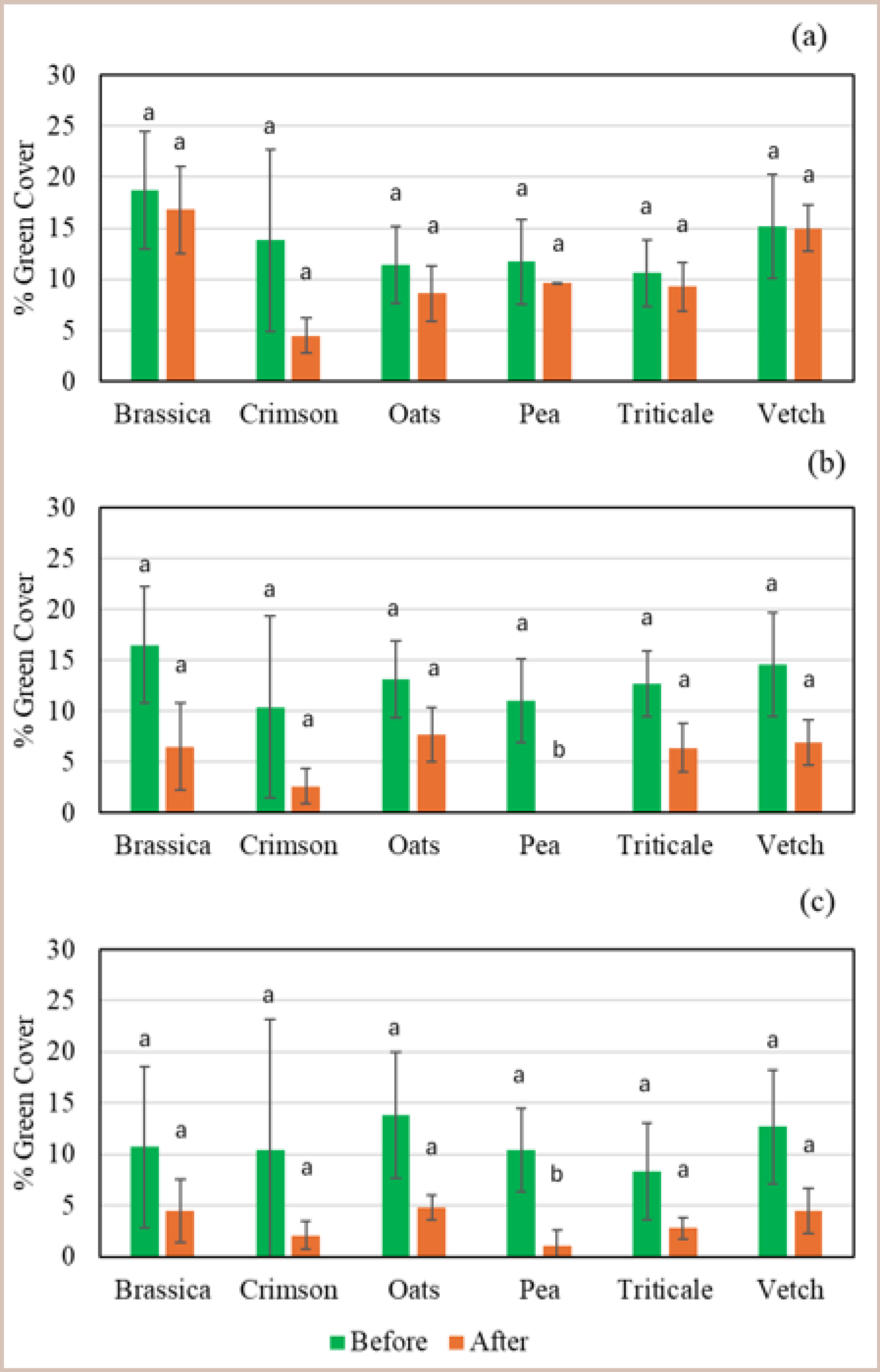


Figure 2: Green cover reduction in (a) check (b) AIM (c) DFT cotton harvest aids from just before spray (green) to two weeks after spray (orange).

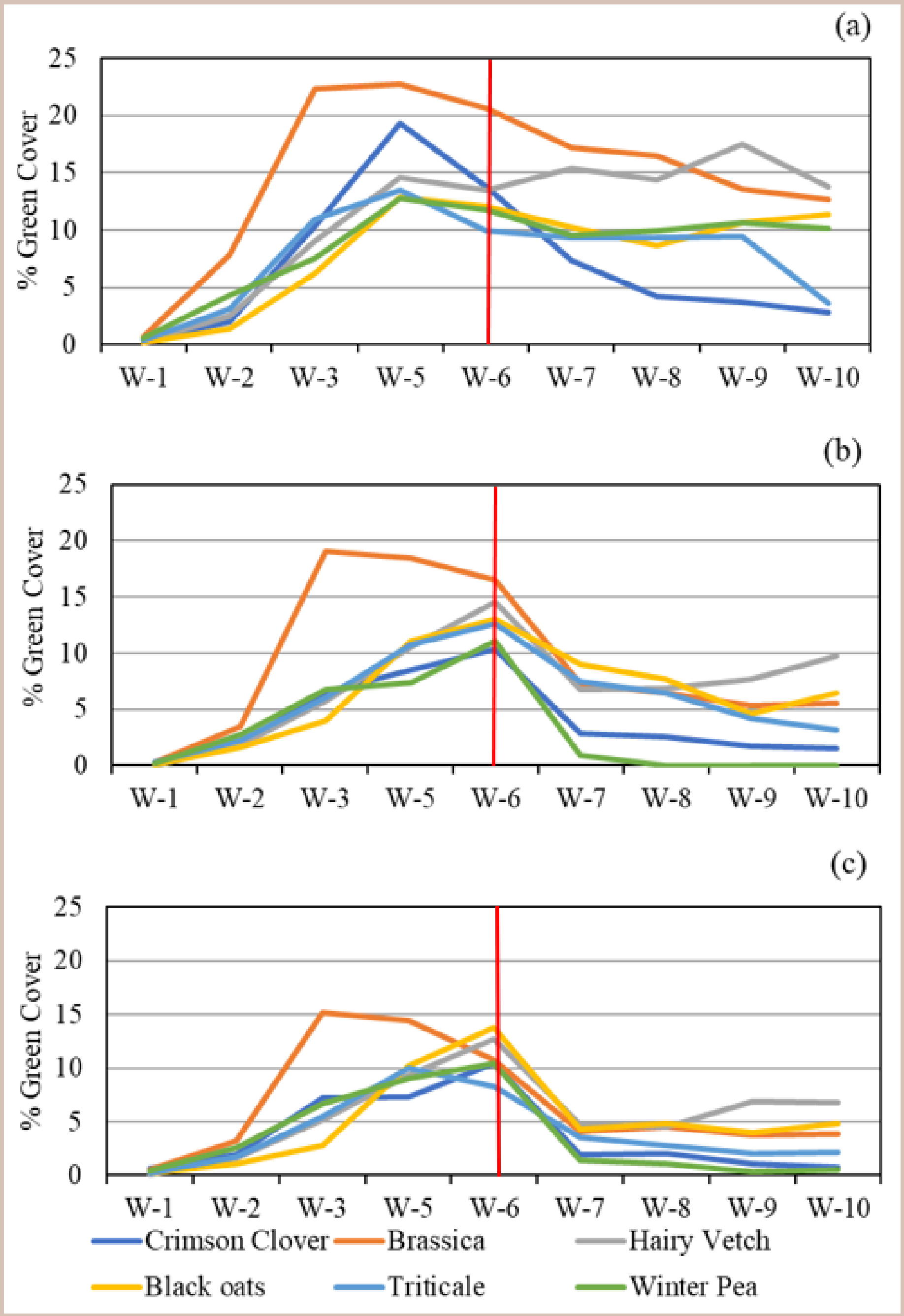


Figure 3: Weekly Green cover percentage in (a) Check (b) AIM (c) DFT cotton harvest aids from Day of planting to the week 10 (W-1 to W-10). Red line indicates spray of cotton harvest aids. No spray was done on check plots.

Conclusion

Cover crops in cotton cropping systems could be a useful option for soil protection during dry and windy winter conditions of the Center High Plains. However, the late harvest of cotton in the region and inclement germination conditions following harvest challenge the establishment of the cover crops. Therefore, establishing covers in a standing cotton crop could be a viable option. This study investigated the effect of cotton harvest aids on cover crops following establishment in growth chambers. Our results show that commonly used cotton harvest aids in the region affect the growth of cover crops and may result in partial to total desiccation of the plants. All cover crops lost almost 60% or more of the biomass within two weeks of spray with DFT, and at least 50% of the biomass when sprayed with AIM. Green cover declined in all crops until week 10, except for hairy vetch and black oats, which showed regrowth by week 10. Further, field studies are required to understand the performance of cover crops when inter-seeded or broadcasted in actively growing cotton and under different weather conditions.

REEVALUATION OF HEAT UNIT ACCUMULATION IN OKLAHOMA COTTON

Brenna A. Cannon, Jason Warren, Josh Lofton, and Jennifer Dudak

ABSTRACT

Historically, all but three counties in Oklahoma have produced cotton on approximately 25% of the state's arable land. The predictable pattern of cotton growth has been defined in other areas of the United States with a heavy focus on the Southeast by several researchers (Oosterhuis, 1990; Supak, 1984). Seasonal heat unit accumulation is inadequate to meet the thresholds set by this research to produce profitable cotton production. However, researchers have begun to identify this issue and reevaluate the number of heat units needed to grow a cost-effective cotton crop (Waddle, 1984; Esparaza et al., 2007). This includes reducing the base heat units needed to produce harvest ready cotton by one-third from 1444(℃) to 1000(℃) heat units (Gwathmey et al., 2016; Howell et al., 2004; Wrona et al., 1996).

This study aims to expand this research to the state of Oklahoma to evaluate the development of cotton in response to heat unit accumulation. Two varieties, Phytogen 332 and 400 W3FE were evaluated in Wakita, Ft. Cobb, Shawnee, and in the panhandle of Oklahoma to better understand the progression of development with heat unit accumulation. Sites were monitored every two weeks to collect growth stage of each variety across the various locations. At the end of the season, plants were randomly selected from uniform areas in the field and mapped to evaluate boll distribution in respect to the accumulated heat units. Preliminary results show a different growth pattern in the field, with more importance placed on vegetative bolls. Therefor the distribution of heat units across the growing season should be altered to more accurately reflect the approximate growth stage based on the point in time heat unit accumulation.

Results and Discussion

Preliminary results from 2023 show the increased importance of vegetative bolls in Oklahoma, as they contribute more to overall yield than plants grown in other regions of the cotton belt. Movement further south in Oklahoma (Figures 5-8) follows typical boll distribution patterns with a high emphasis on cotton lint in the midsection of the plant on first and second position bolls. However, in more northern and western locations (Figure 1-4), boll distribution changed as temperatures became less ideal for cotton production and other stressors influencing the behavioral patterns of plant development. Shawnee and Wakita had similar heat unit accumulation despite their difference in latitude. Wakita and the panhandle are at similar latitudes but had different stressors as the panhandle location was irrigated and Wakita was not. Phytogen 400 generally wanted to act as a later maturing variety but was limited by the limited heat units. Some of these characteristics can be hereditary, as seen by the various maturities, but seasonal conditions and other stressors can impact the development patterns.

Conclusion

Despite developmental differences and a short-season environment cotton production maintains economic viability in Oklahoma. However, these differences in the developmental pattern can dictate management decisions across the state. These patterns can also alter the time required to reach critical growth stages compared to traditional development charts. With this information, it is critical to continue to evaluate multiple varieties in various environments across the state to begin to parse out an approximated heat unit accumulation chart with the reduced base threshold previously proposed for the High Plains.

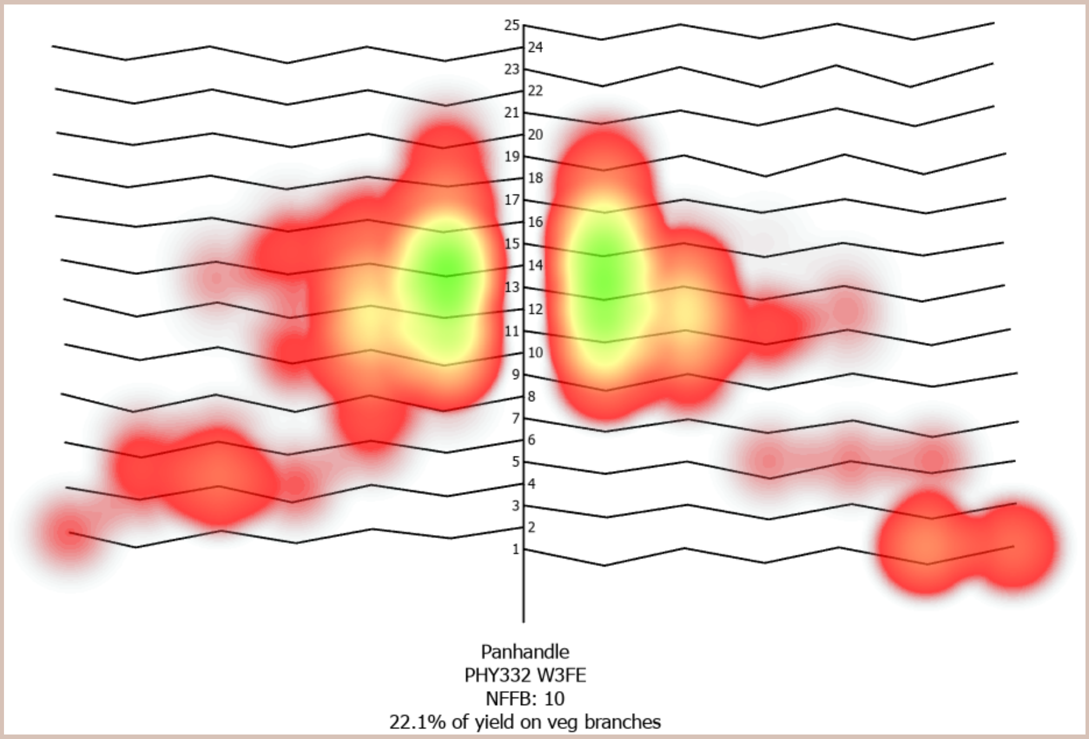


Figure 2. Cotton plant schematic of the average plant from Phytogen 332 W3FE from the Panhandle of Oklahoma.

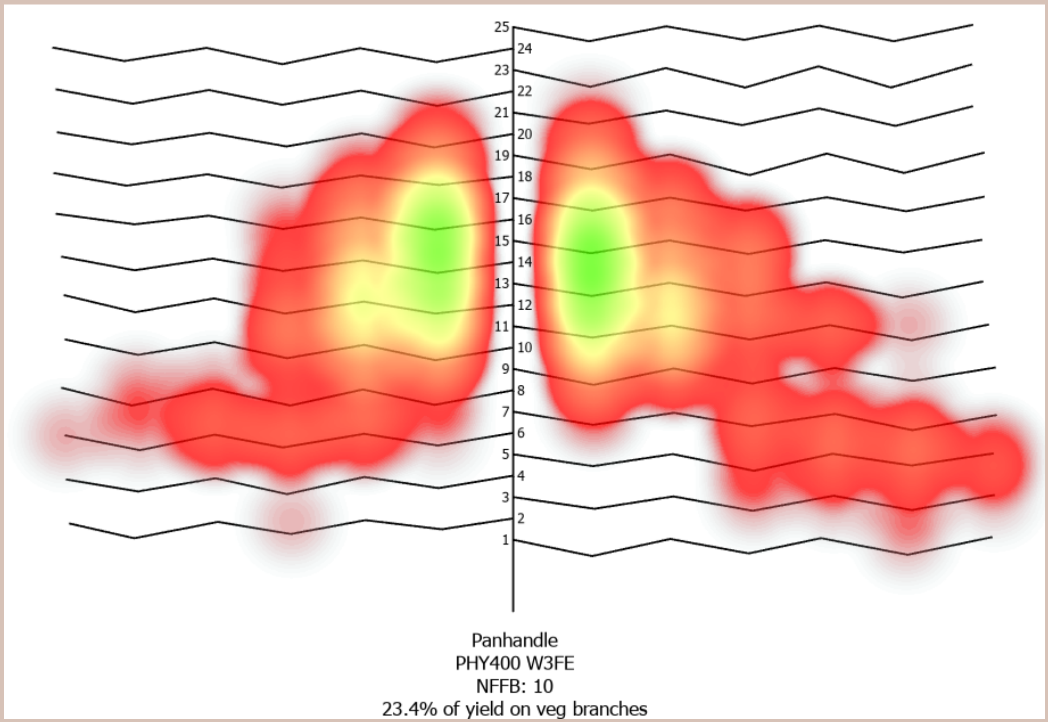


Figure 3. Cotton plant schematic of the average plant from Phytogen 400 W3FE from the Panhandle of Oklahoma.

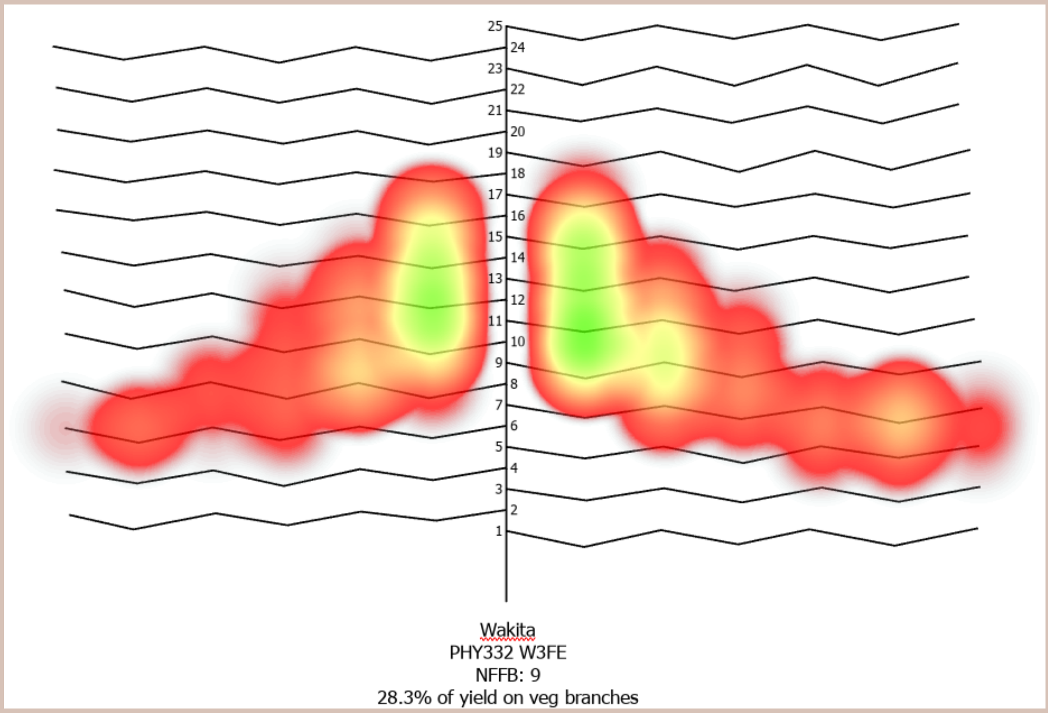


Figure 3. Cotton plant schematic of the average plant from Phytogen 332 W3FE from Wakita, Oklahoma.

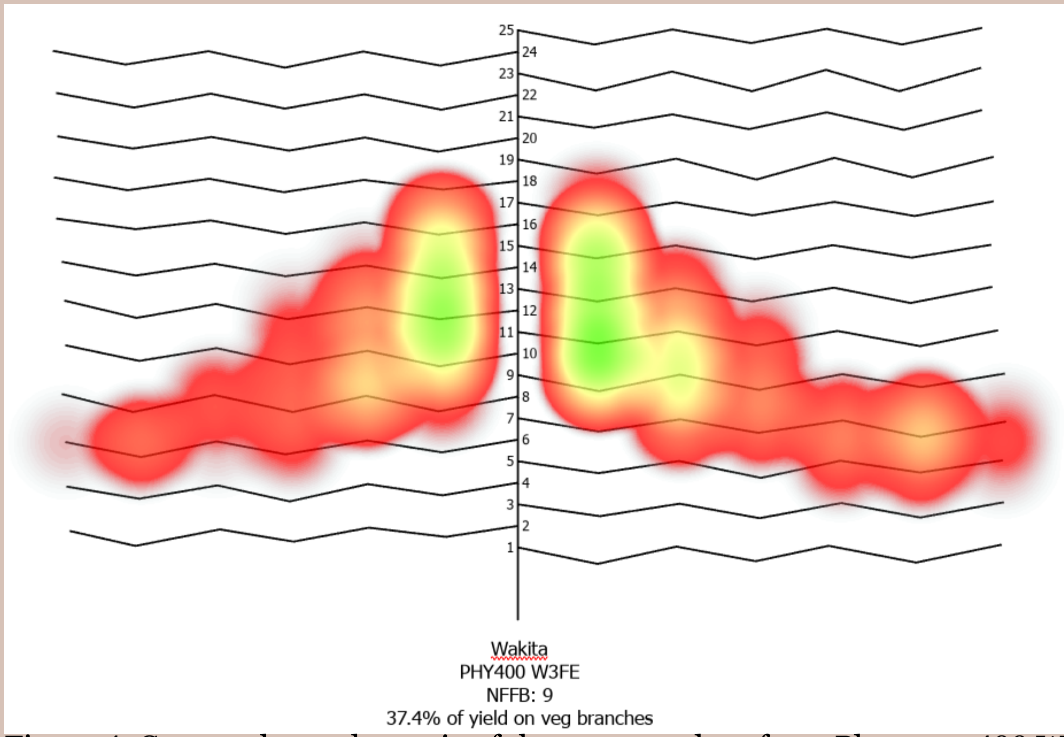


Figure 4. Cotton plant schematic of the average plant from Phytogen 400 W3FE from Wakita, Oklahoma.

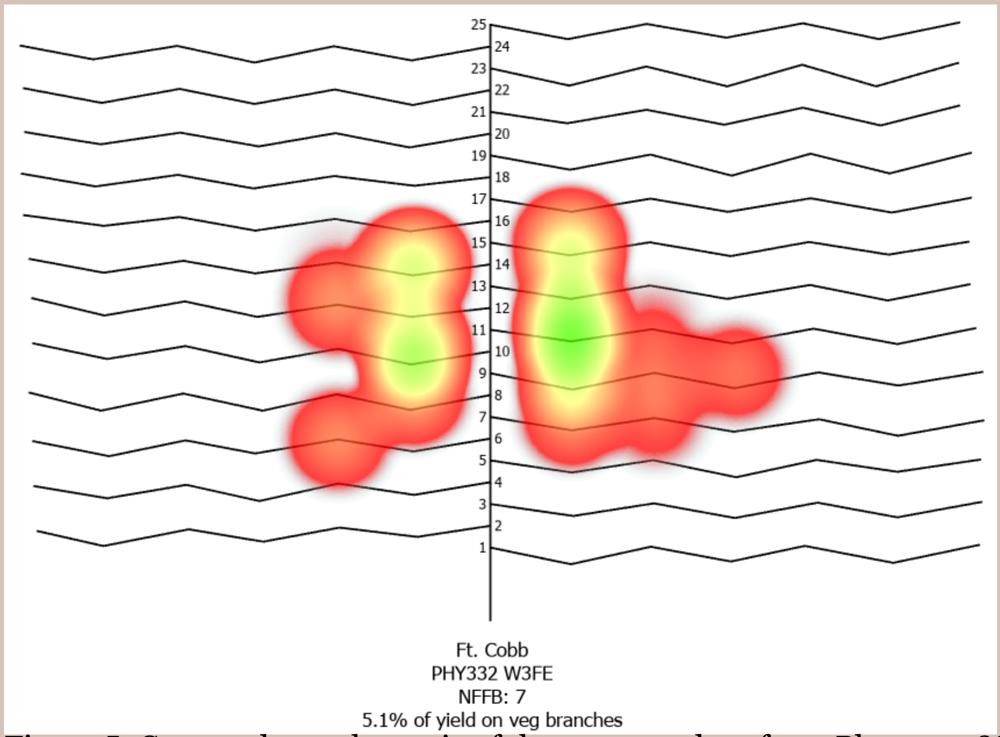


Figure 5. Cotton plant schematic of the average plant from Phytogen 332 W3FE from Ft. Cobb, Oklahoma.

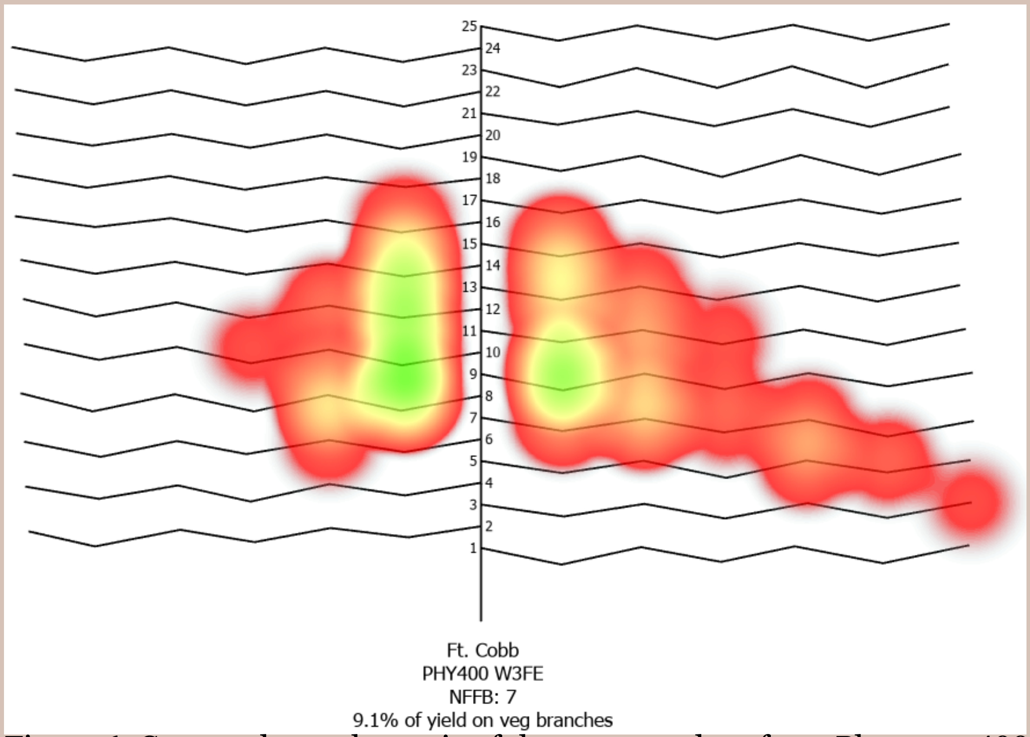


Figure 6. Cotton plant schematic of the average plant from Phytogen 400 W3FE from Ft. Cobb, Oklahoma.

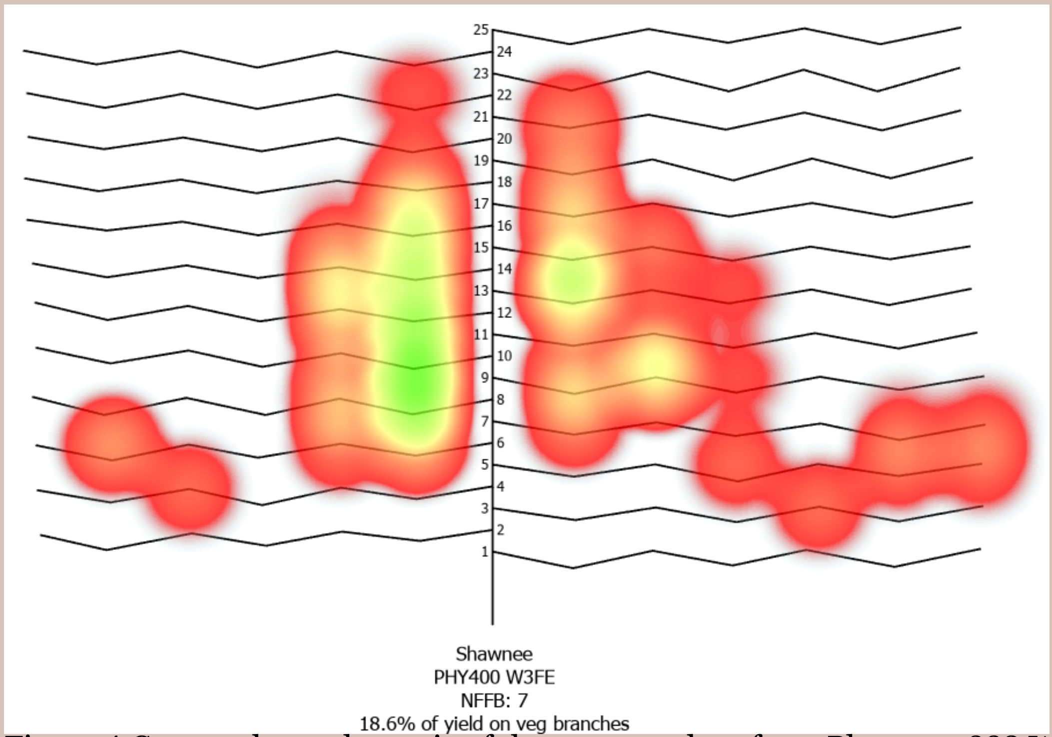


Figure 4.Cotton plant schematic of the average plant from Phytogen 332 W3FE from Shawnee, Oklahoma.

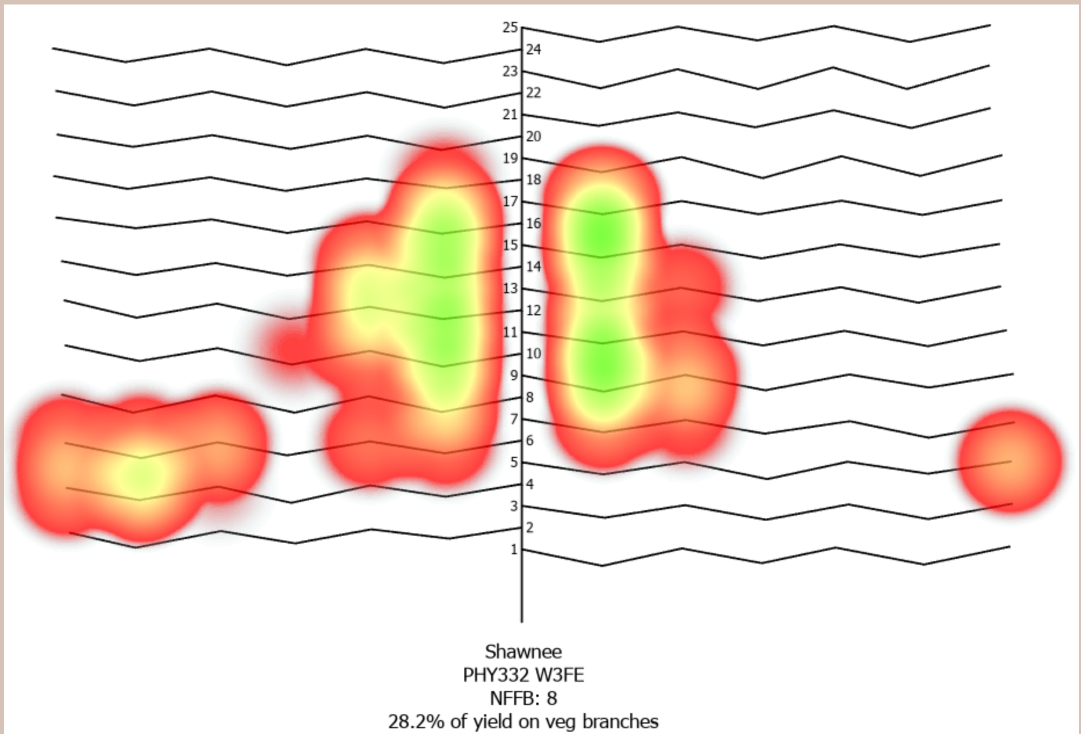


Figure 5.Cotton plant schematic of the average plant from Phytogen 400 W3FE from Shawnee, Oklahoma.

IIRRIGATED ROTATIONAL AND CONTINUOUS COTTON PRODUCTION AT LIMITED WELL CAPACITIES IN THE SOUTHERN GREAT PLAINS

Digvijay Mohite and Sumit Sharma

ABSTRACT

The Oklahoma Panhandle, reliant on the rapidly depleting Ogallala Aquifer, faces significant challenges in sustaining irrigated agriculture, particularly for water-intensive crops like corn. Corn-cotton rotational systems, evaluated in a 2022–2023 field experiment in Goodwell, Oklahoma, under center pivot irrigation, offer a sustainable strategy to conserve water and maintain economic viability. A field experiment conducted in Goodwell, Oklahoma, from 2022 to 2023 under center pivot irrigation evaluated continuous and rotational (with corn) cotton production at irrigation capacities of 250, 350, and 450 GPM. Implemented in a randomized complete block design with four replications, the study assessed plant growth parameters (nodes, height, leaf area index, cotton weight), soil moisture using Sentek probes, and yield and fiber quality data. Managed according to Oklahoma State University's standard practices, the experiment analyzed data with SAS 9.4. Results indicate that rotational cotton systems outperform continuous cotton in yield and resource efficiency, supporting the adoption of less water-intensive cropping systems. These findings highlight the potential of rotational cotton to reduce groundwater withdrawal rates, extend aquifer longevity, and maintain farm income under varying irrigation capacities in the Southern Great Plains.

Figure 1. Distribution of yield for rotational and continuous cotton in 2022 at different irrigation treatments.

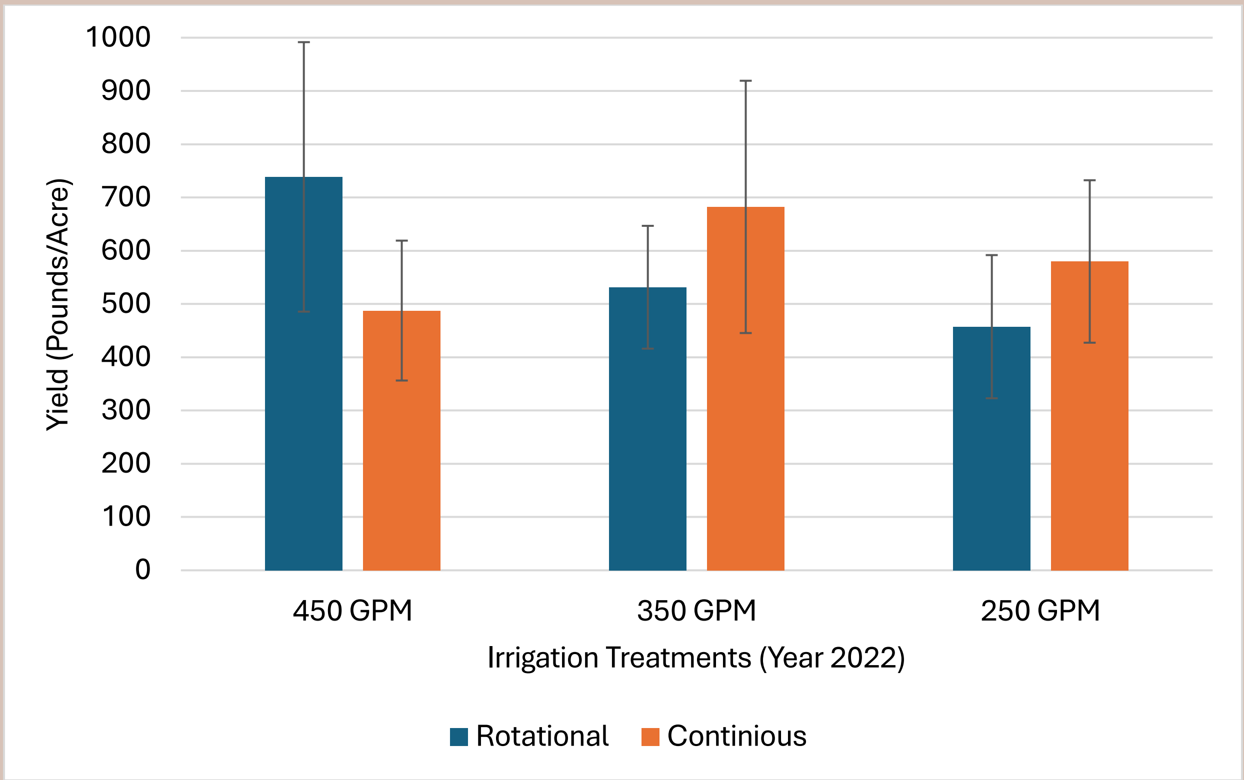
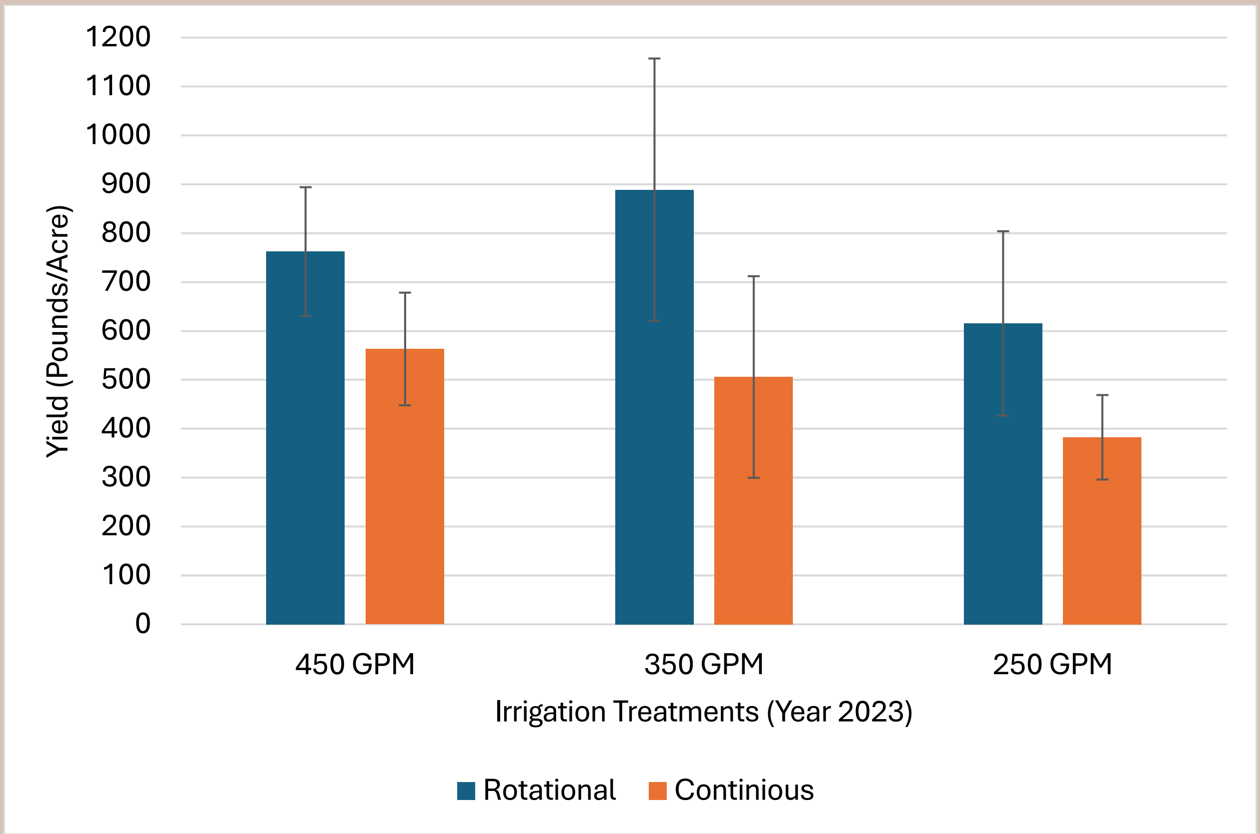


Figure 2. Distribution of yield for rotational and continuous cotton in 2023 at different irrigation treatments.



Conclusion

The 2022–2023 field experiment in Goodwell, Oklahoma, demonstrates that rotational cotton systems, integrated with corn, outperform continuous cotton production in yield and water use efficiency under irrigation capacities of 250, 350, and 450 GPM. By leveraging a randomized complete block design and comprehensive data collection on plant growth, soil moisture, yield, and fiber quality, the study underscores the viability of rotational systems in addressing the declining Ogallala Aquifer levels. These systems reduce groundwater withdrawal rates while maintaining farm profitability, aligning with sustainable agricultural practices. The adoption of rotational cotton, supported by precision irrigation and standard management practices, offers a promising strategy to extend aquifer longevity and ensure economic resilience in the Southern Great Plains.

INVESTIGATING THE IMPACT OF COVER CROPS ON GREENHOUSE GAS EMISSIONS IN THE SOUTHERN GREAT PLAINS REGION

Tristian Williams, Sumit Sharma, Jason Warren, and Mary Foltz

ABSTRACT

The agriculture sector has been estimated to be responsible for a significant portion of greenhouse gas emissions worldwide. Cover crops have been found to improve soil health by increasing soil organic matter, recycling nutrients, and reducing erosion. The objective of this project was to understand the effects of cover crops on greenhouse gas emissions, specifically in the Southern Great Plains. Nitrous oxide (N_2O) and carbon dioxide (CO_2) gas emissions were measured using steady-state gas flux chambers in a winter wheat-cotton cropping system rotation at Caddo Research Station in Ft. Cobb, Oklahoma. Winter wheat was planted as the cover crop with early termination, late termination, and no cover as main treatments. The gas samples were collected weekly in glass vials and were analyzed using a Varian-450 gas chromatograph (GC). The average gas emissions are estimated during the cover crop phase and cotton production phase. The flux of both gases was calculated using linear regression analysis and the ideal gas law, and the means of each treatment were compared for significance. Primary results of this study found no significant difference in N_2O and CO_2 emissions across the cover crop treatments during the cover crop phase and cotton production phase. However, there was a significant difference between average N_2O and CO_2 emissions in 2023 and 2024, likely attributed to temperature and moisture variability. Additionally, N_2O emissions were significantly higher in the cotton production phase than the cover crop phase in both years, indicating that nitrogen fertilizer may also play a role in N_2O emissions. In contrast, CO_2 emissions varied widely between crop phases and may depend on differences in weather, microbial activity, and decomposition rates. The results of this study highlight the variability of the efficiency of cover crops to mitigate greenhouse gas emissions, specifically in regions where weather conditions can be unpredictable, and drought is prevalent.

Table

CO_2 and N_2O fluxes average across cover crop treatments in years 2023 and 2024.

Year	Phase	N_2O	CO_2
		mg/m²/hr	
2023			
	Cotton	0.018a	19.54a
	Cover Crop	0.003b	8.54b
2024			
	Cotton	0.073a	24.8a
	Cover Crop	0.045b	30.6a

Figure

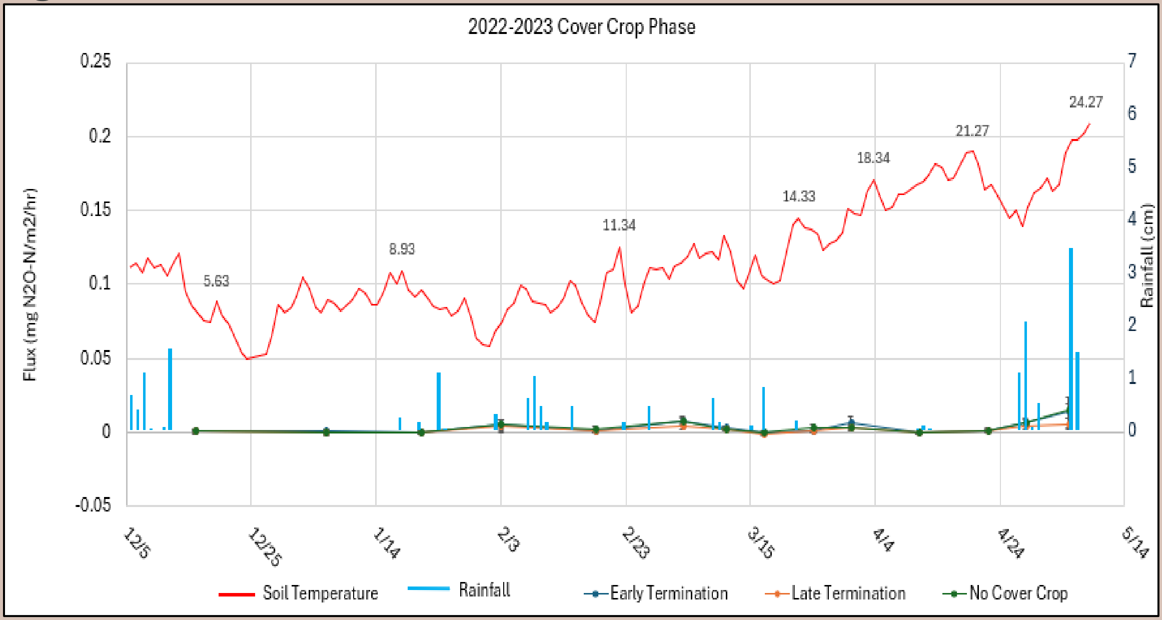


Figure 6: N_2O emissions and weather conditions from the 2022-2023 cover crop phase.

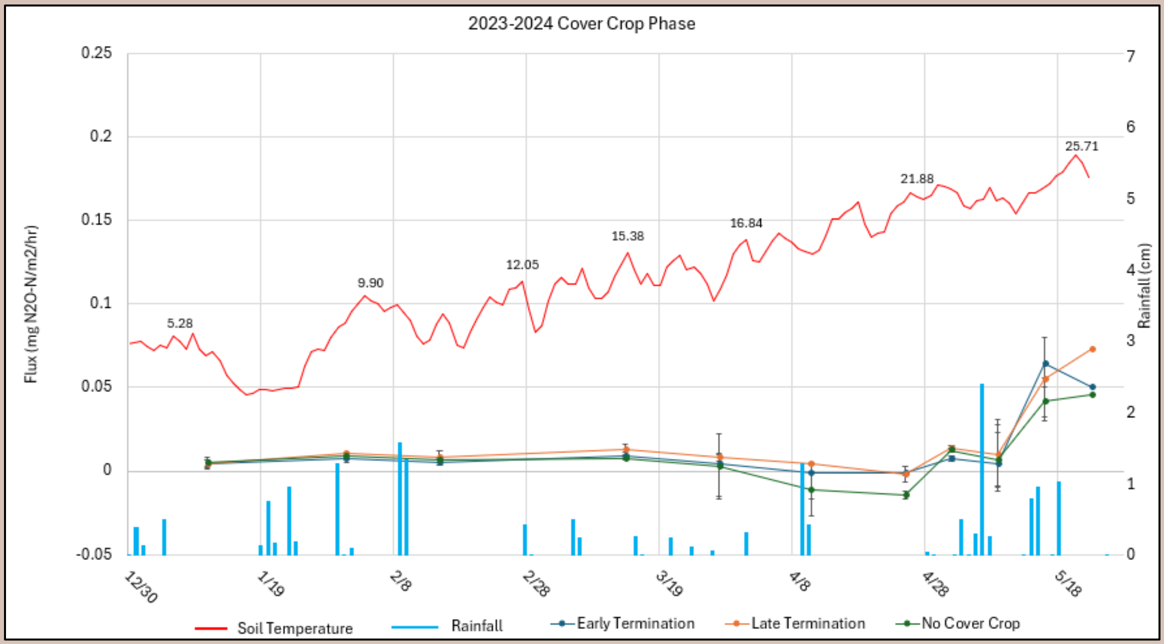


Figure 7: N_2O emissions and weather conditions from the 2023-2024 cover crop phase.

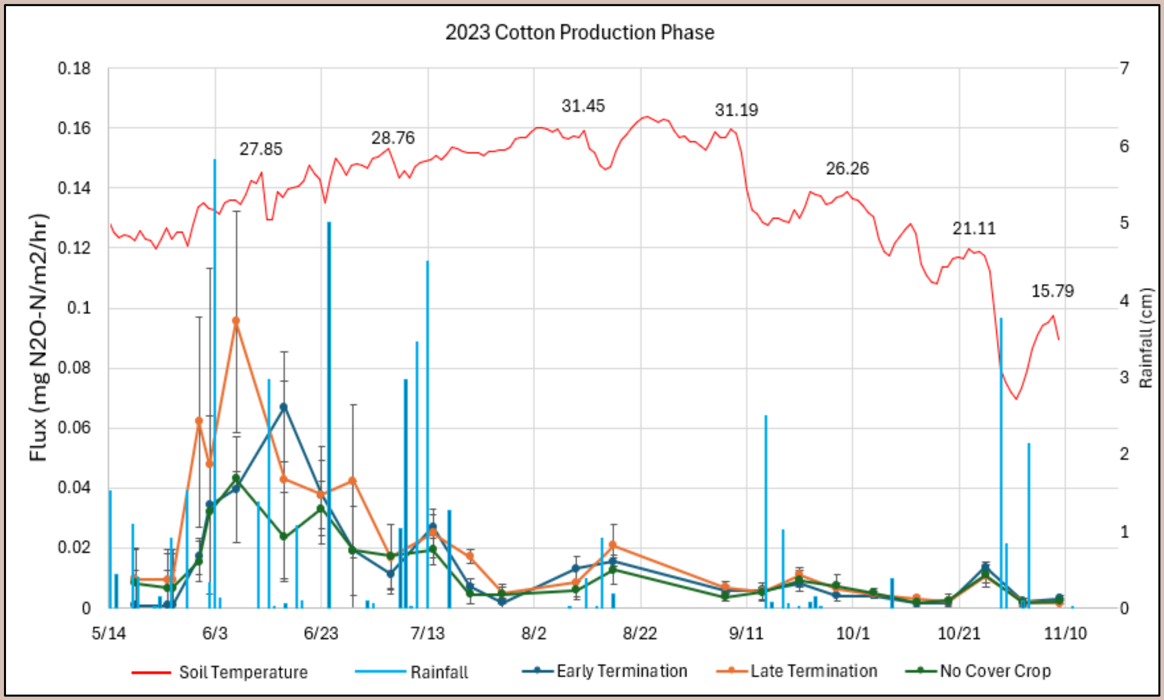


Figure 8: N_2O emissions and weather conditions in the 2023 cotton production phase.

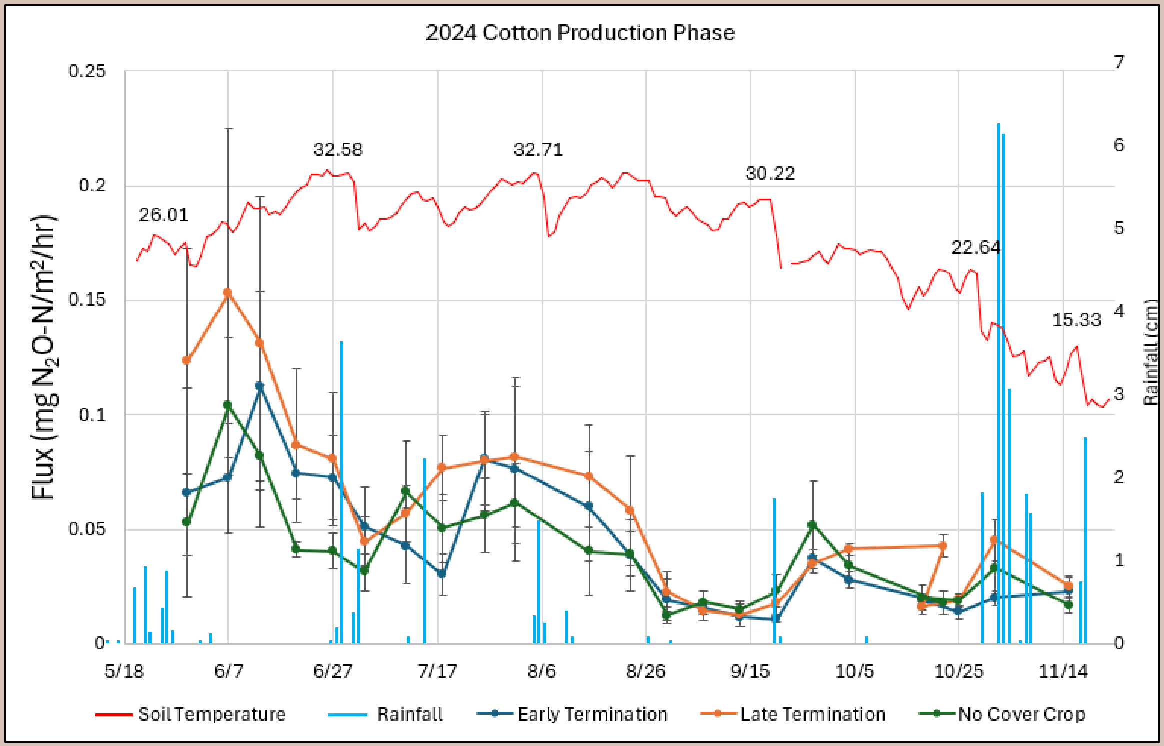


Figure 9: N_2O emissions and weather conditions in the 2024 cotton production phase.

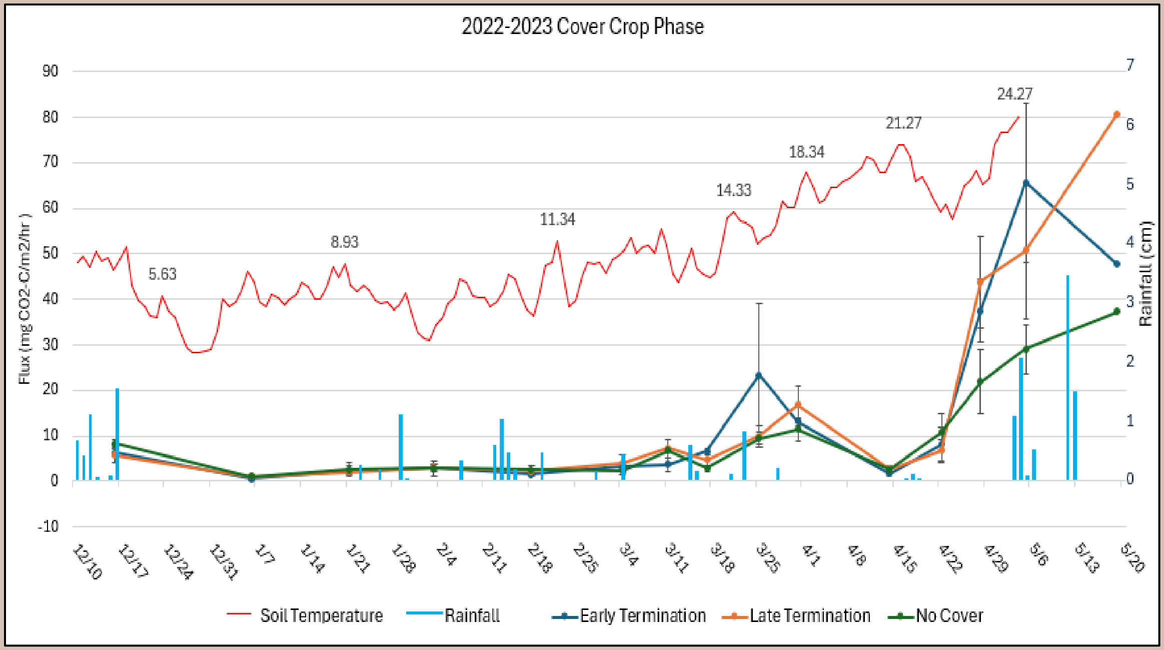


Figure 10: CO_2 emissions and weather conditions in the 2022-2023 cover crop phase.

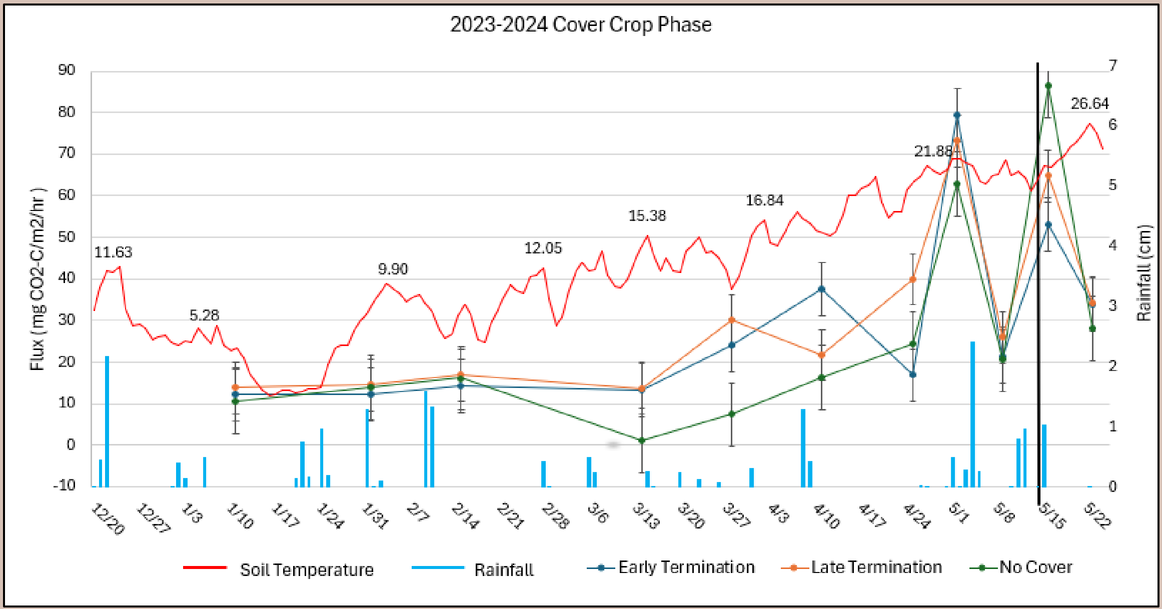


Figure 11: CO_2 emissions and weather conditions in the 2023-2024 cover crop phase.

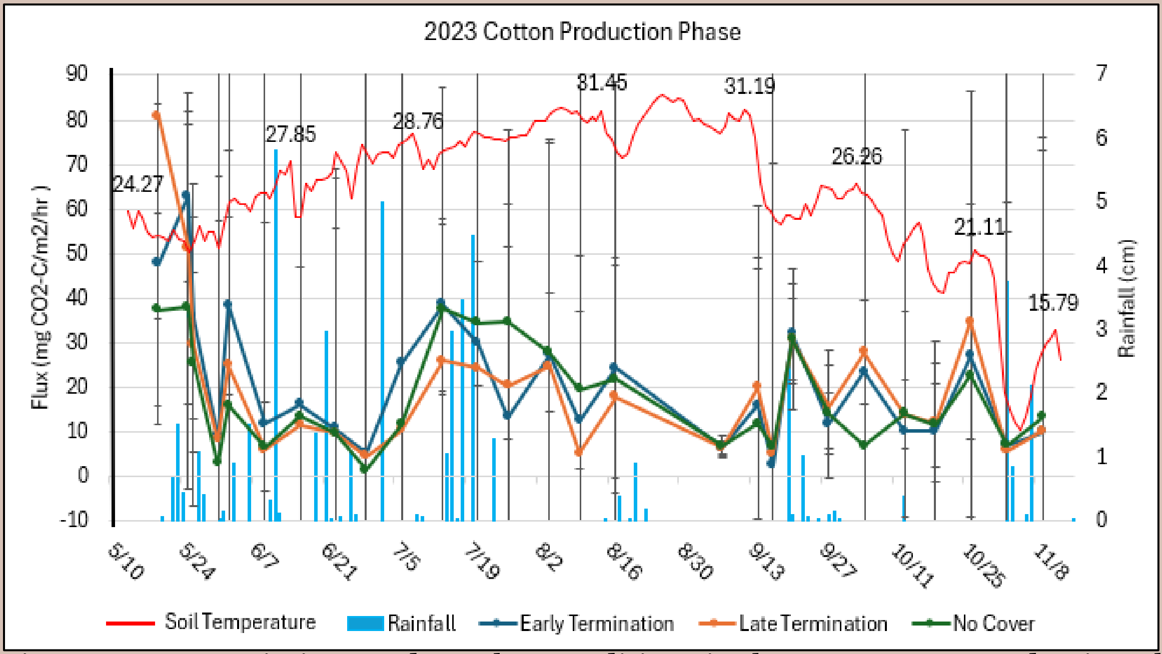


Figure 12: CO_2 emissions and weather conditions in the 2024 cotton production phase.

Conclusion

Although cover crops can provide many beneficial ecosystem functions, their impact on greenhouse gas emissions may be limited by weather and climatic conditions. The presence of cover crops nor their termination timings produced a significant difference in emissions compared to the no cover crop plots. However, there was a significant difference in mean GHG fluxes between 2023 and 2024. There was also a significant difference between the cover crop phase and the cotton production phase of 2024. Observing rainfall and soil temperature data from the Mesonet station shows higher average temperatures in 10 out of 12 months for 2024 and less overall precipitation. Emissions data suggests that factors such as variability in precipitation and high temperatures played a role in the high N_2O emissions and the wide variability of CO_2 emissions. Low moisture likely limits the activity of microbes in the soil, thus limiting the nutrient cycling capability of the soil. Furthermore, high temperatures would continue to dry out the soil. Because higher N_2O emissions were found in the cotton production phase of both years, it is probable that nitrogen fertilization events also drove N_2O emissions. Decomposition rates of the cover crop may have affected CO_2 emissions during the cotton production phase where crop growth was at its highest. Further research is needed to determine the combined effects of weather and management practices on GHG emissions by introducing cover crops in cropping systems of the Southern Great Plains.

CORN PRODUCTION UNDER LIMITED IRRIGATION IN THE SOUTHERN GREAT PLAINS

Mark Anthony M. Barbadillo, Sumit Sharma, Digvijay Mohite, and Harsanjam Singh Randhawa

ABSTRACT

A limited irrigation strategy that uses a reduced percentage of the crop's full water requirement was implemented in the Oklahoma Panhandle during 2023 and 2024. It was done to assess the yield performance of corn hybrids under water-limited conditions. The experiment was carried out in a randomized complete block design nested in irrigation as main plot with hybrids as subplots. The irrigation treatments were not replicated. In 2023, the irrigation treatments were 310, 368, and 406 mm and the hybrids used were P13476Q, P12904Q, P17677Q, and P1828Q. Water stress was induced late in the growing season. In 2024, the irrigation treatments were 349 mm applied at the early stage, 330 mm applied at the late stage, and 413 mm strategically applied throughout the corn water-sensitive stages. Six corn hybrids were used including P13476Q, P12904Q, P17677Q, P10625, P13777, and P12903. Grain yield and kernel count and weight were determined and were normalized at 15.5 % grain moisture content. Water and irrigation use efficiencies (WUE and IUE) were determined using the normalized grain yield data and the amounts of rainfall received, and irrigation used throughout the growing season. Analysis of variance and Tukey's HSD test were done at 5 % level of significance. For both years, significant differences in grain yields, WUE, and IUE were found between hybrids applied with reduced irrigation amounts (310 mm in 2023 and, 330 and 349 mm in 2024). Under reduced irrigation, significantly higher grain yield, WUE, and IUE were obtained by P13476Q (6.5 Mg ha^{-1}, 0.93 Kg m^{-3}, and 2.26 Kg m^{-3}, respectively) relative to hybrids P17677Q (3.27 Mg ha^{-1}, 0.47 Kg m^{-3}, and 1.13 Kg m^{-3}, respectively) and P1828Q (3.58 Mg ha^{-1}, 0.52 Kg m^{-3}, and 1.25 Kg m^{-3}, respectively) in 2023. In 2024, highest grain yield, WUE, and IUE were obtained by P13777 (10.6 Mg ha^{-1}, 1.16 Kg m^{-3}, and 2.43 Kg m^{-3}, respectively) when early water stress was imposed. Water stress imposed late in the growing season resulted in relatively high grain yield, WUE, and IUE for P10625 (10.7 Mg ha^{-1}, 1.19 Kg m^{-3}, and 2.52 Kg m^{-3}, respectively). For both years, under reduced irrigation, kernel count and weight were not significantly different between hybrids. In

areas where water is most limited (i.e., limited irrigation and rainfall), greatest variability in grain yield, WUE, and IUE occur. In years with normal seasonal precipitation, hybrid maturity days play a crucial role in these variabilities when water-stress is imposed late in the growing season.

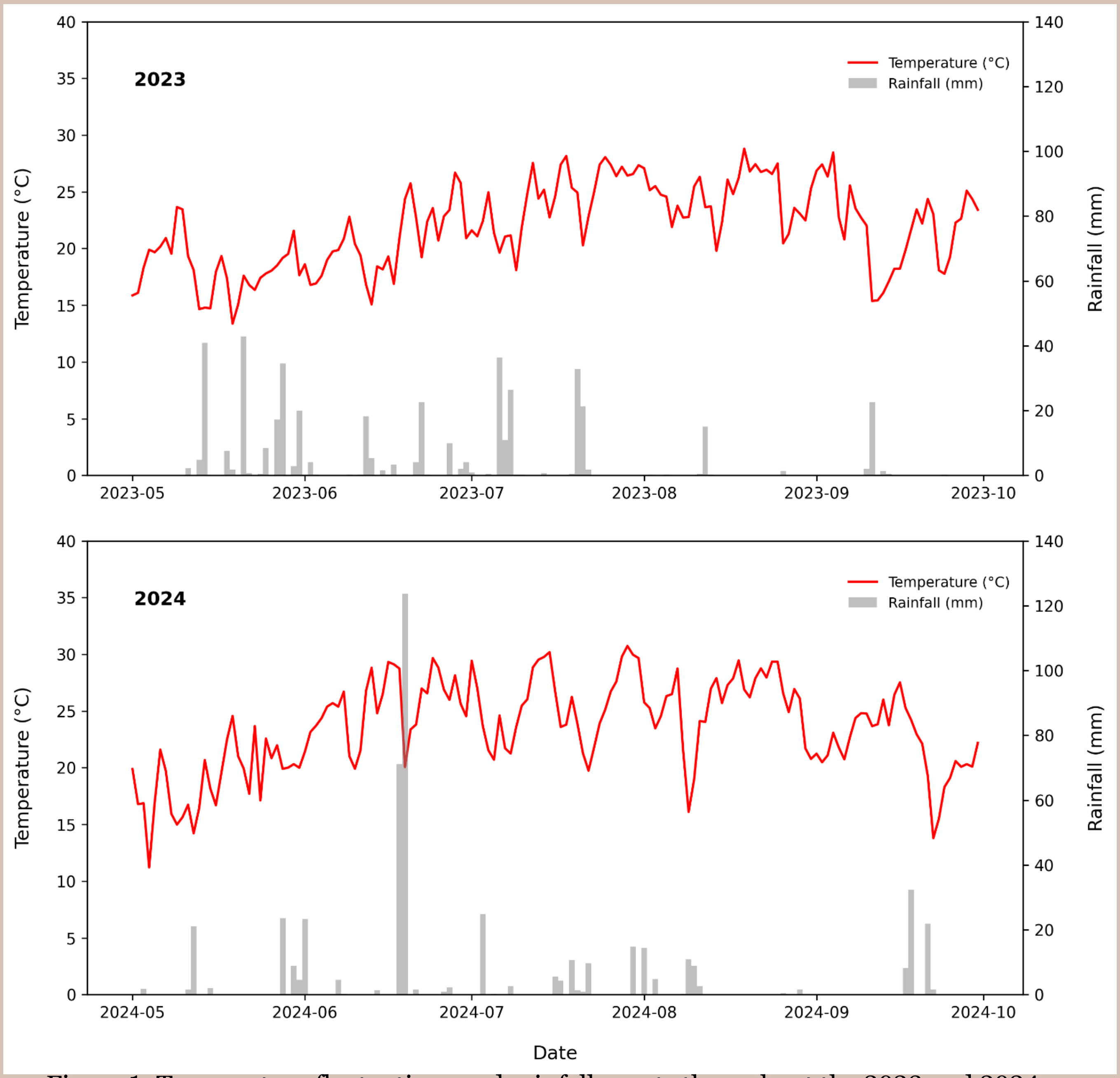


Figure 1. Temperature fluctuations and rainfall events throughout the 2023 and 2024 corn growing seasons. **Note**: The meteorological data were obtained from the Oklahoma Mesonet (https://www.mesonet.org/past-data/mesonet-resources?ref=1660).

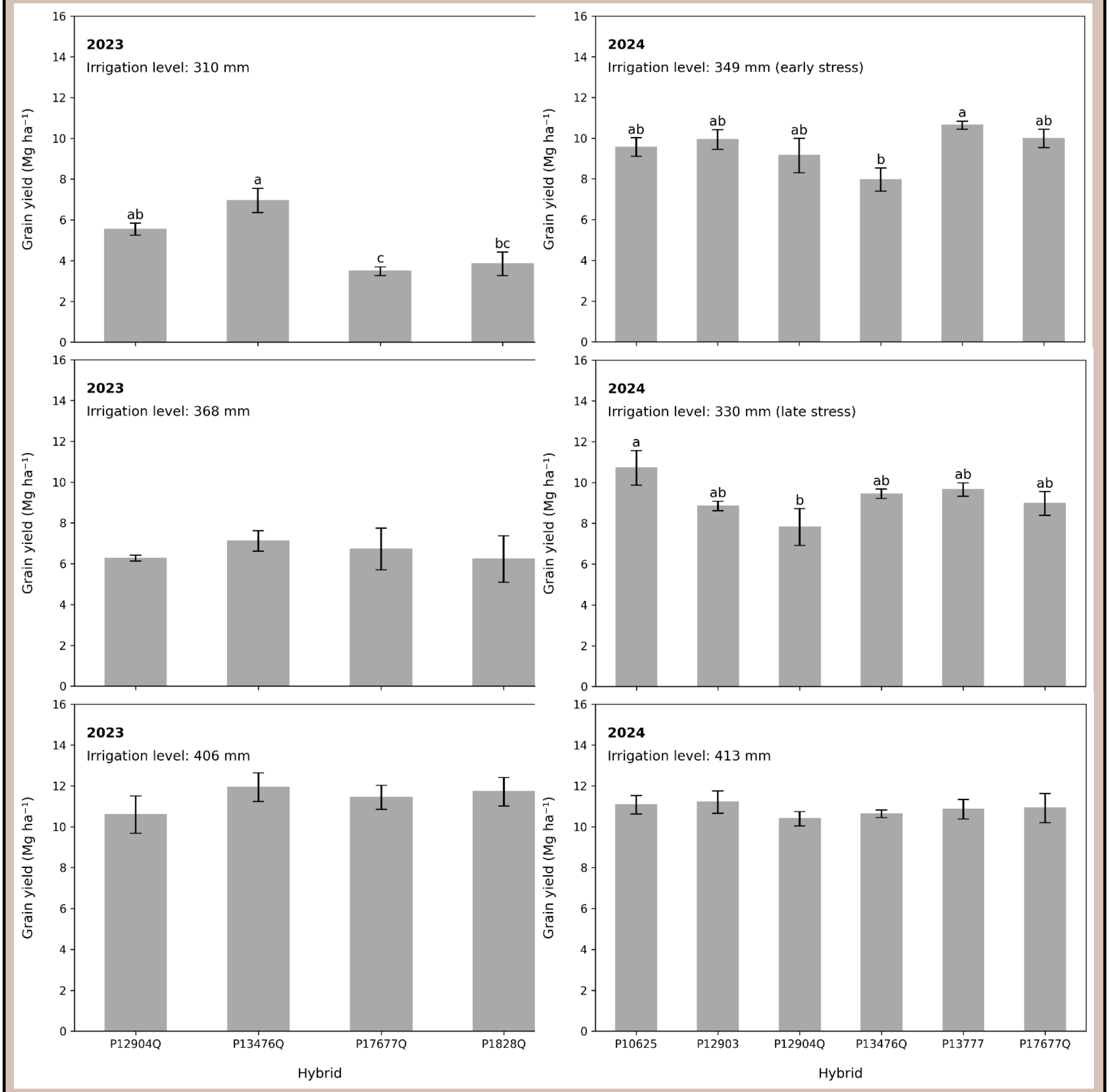


Figure 2. Grain yield (Mg ha^{-1}) of corn hybrids under variable irrigation levels in the Southern Great Plains for 2023 and 2024. *Means with the same letter are not significantly different at α = 0.05.*

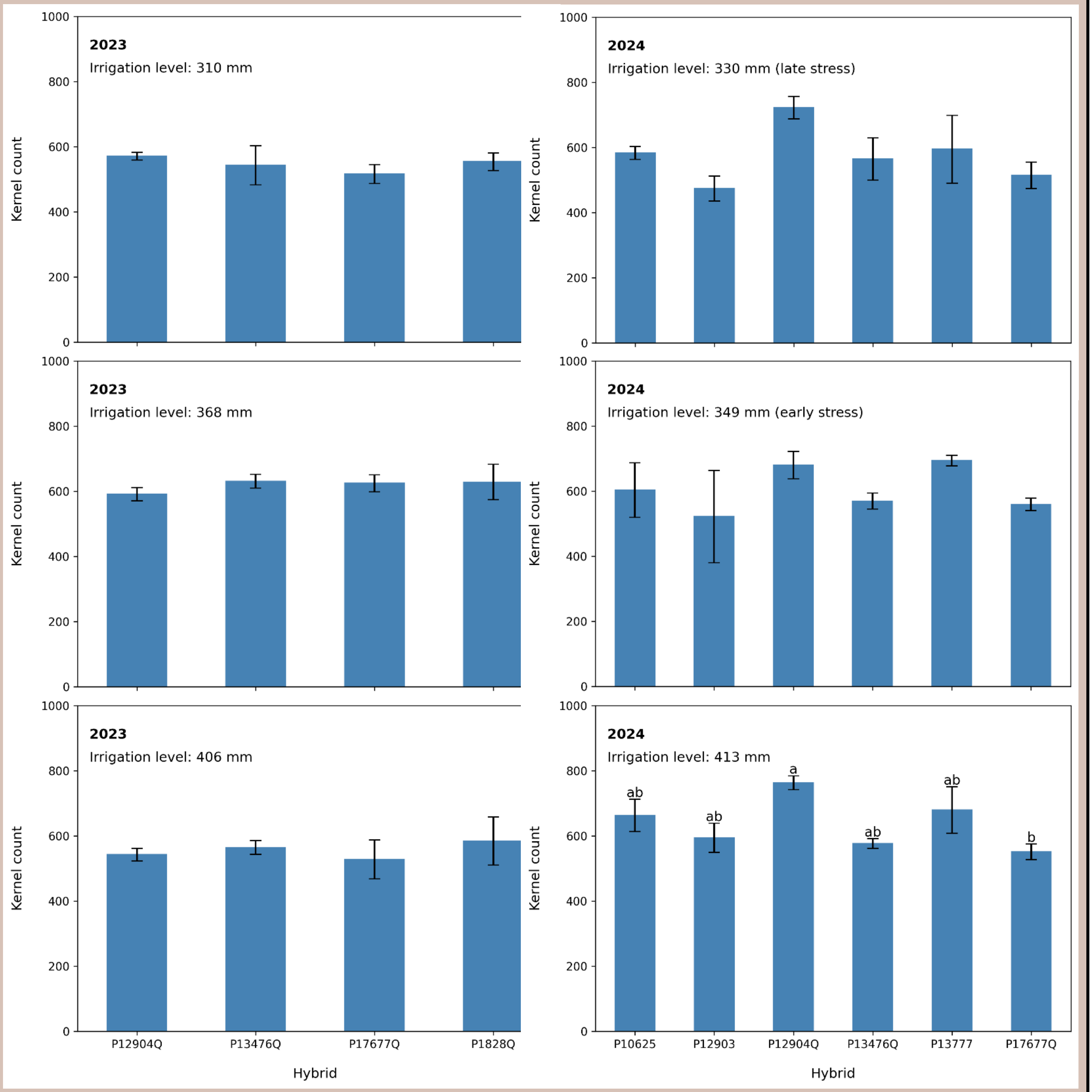


Figure 3. Kernel count of corn hybrids under variable irrigation levels in the Southern Great Plains for 2023 and 2024. *Means with the same letter are not significantly different at α = 0.05.*

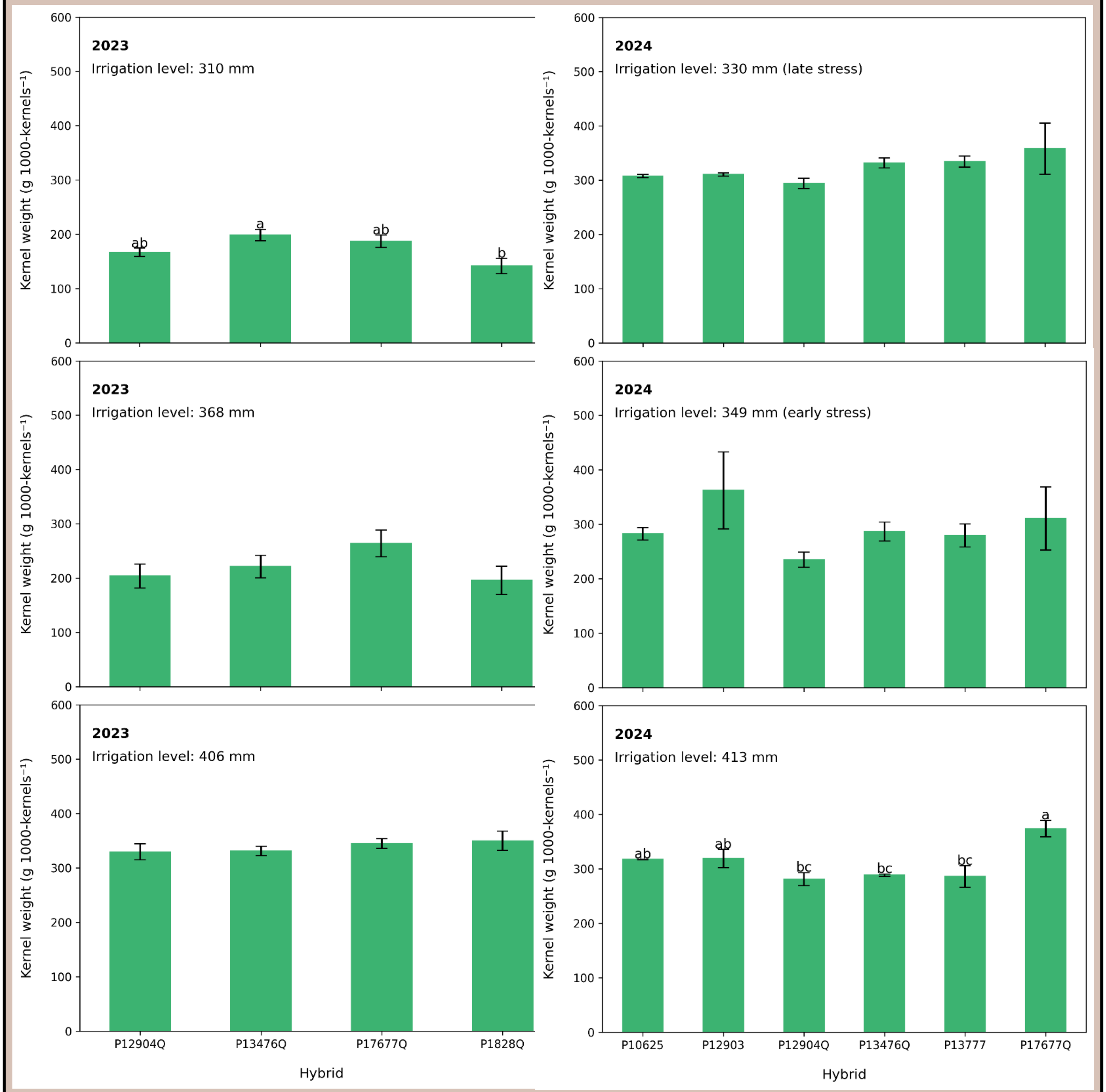


Figure 4. Kernel weight (g 1000-kernels^{-1}) of corn hybrids under variable irrigation levels in the Southern Great Plains for 2023 and 2024. *Means with the same letter are not significantly different at α = 0.05.*

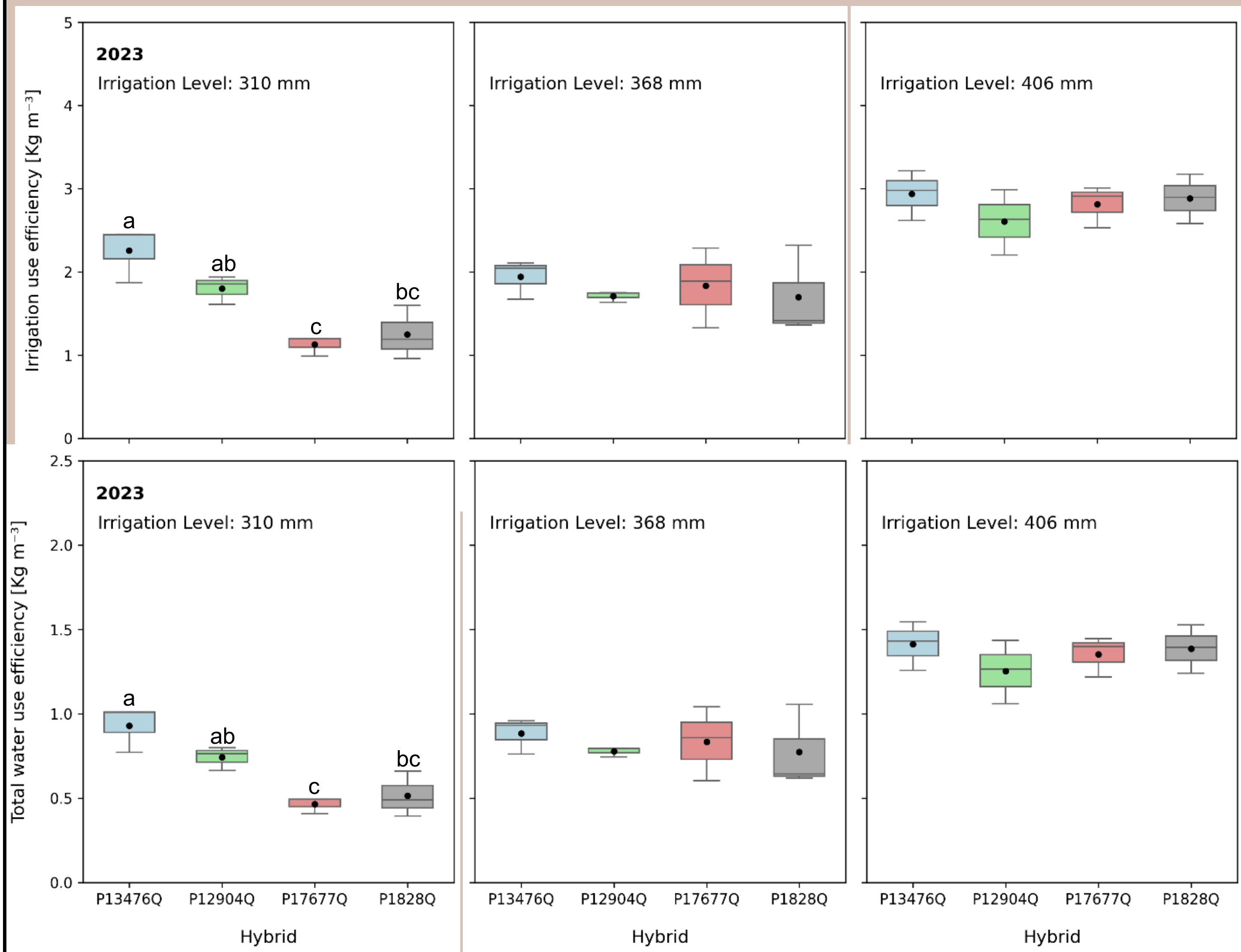


Figure 5. Irrigation and total water use efficiency (Kg m^{-3}) of corn hybrids under variable irrigation levels in the Southern Great Plains for 2023. **Note:** Total water use efficiency includes the amount of water received as irrigation and rainfall. *Means with the same letter are not significantly different at α = 0.05.*

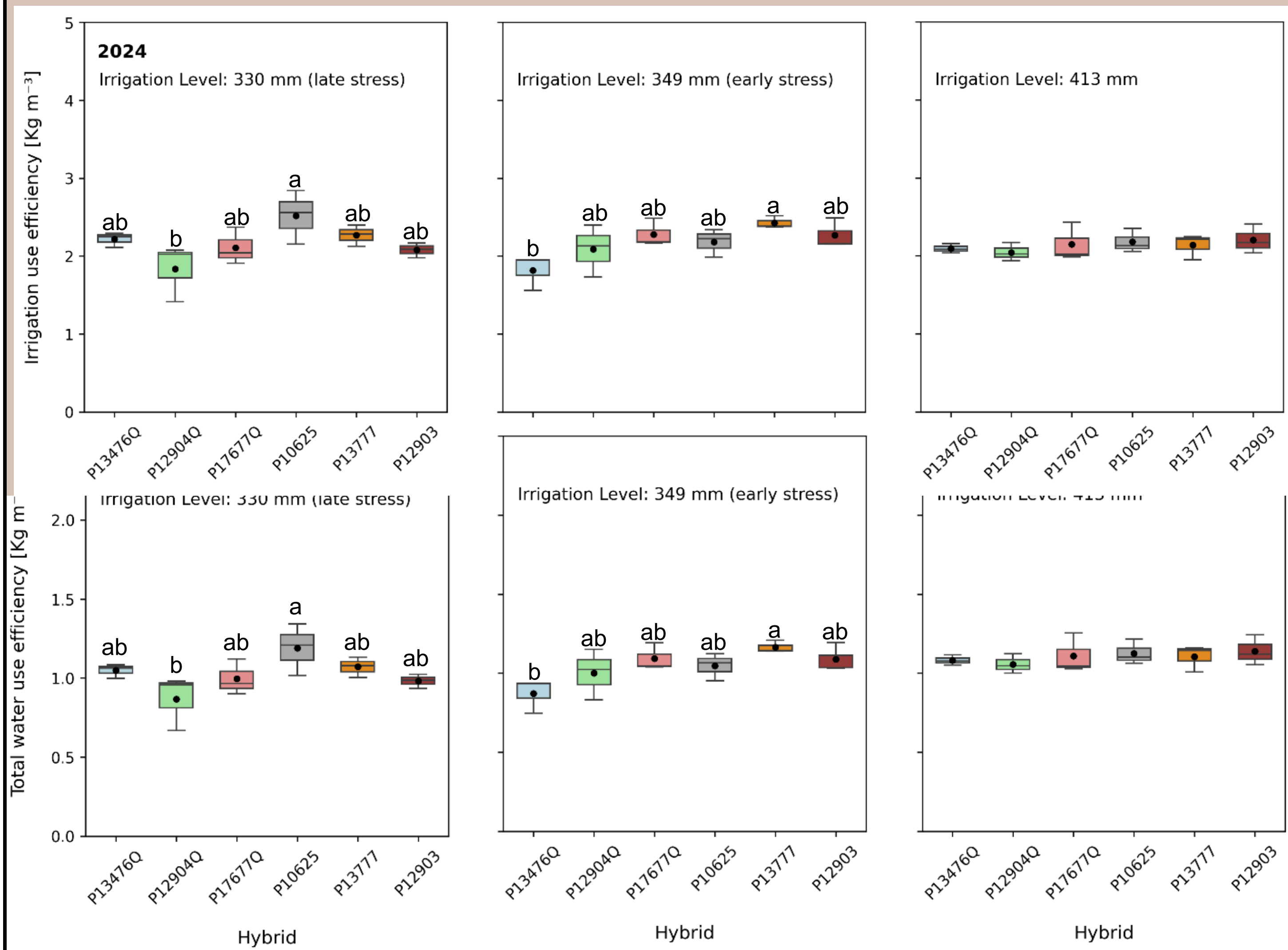


Figure 6. Irrigation and total water use efficiency (Kg m^{-3}) of corn hybrids under variable irrigation levels in the Southern Great Plains for 2024. **Note:** Total water use efficiency includes the amount of water received as irrigation and rainfall. *Means with the same letter are not significantly different at α = 0.05.*

Conclusion

In general, corn hybrids show variable results in grain yield, WUE, and IUE under very limited irrigation. Water stress induced late in the growing season may increase the grain yield variability between hybrids. Relative maturity days play an important role in grain yield production, especially when limited irrigation is applied late in the season when rainfall is also limited. Under these conditions, hybrids with shorter maturity days may produce relatively higher yields than those with longer maturity days. The WUE and IUE under different irrigation levels do not seem to differ when rainfall is evenly distributed throughout the growing season, regardless of the timing of irrigation application.

OPTIMIZING INPUTS FOR CORN PRODUCTION IN THE OKLAHOMA PANHANDLE

Aicha Biaou, Steve Phillips, Sumit Sharma, and Roy Grant

ABSTRACT

This study investigates how multispectral and thermal UAV imagery can refine nitrogen and irrigation management in a corn experiment consisting of 107 plots in the Oklahoma Panhandle. Four nitrogen rates (0, 100, 175, 250 lb N acre^{-1}), three irrigation regimes (16, 20, 24 inches), and three plant population targets (24 k, 28 k, 32 k plants acre^{-1}) are factorially arranged as a split-plot design across the field. Six UAV flights during the growing season acquire paired multispectral and thermal datasets. Vegetation indices such as NDVI and GNDVI quantify nitrogen status, while thermal imagery yields a thermal stress index to flag water related stress. A composite stress layer is created by removing the nitrogen stress signal from overall canopy stress, isolating water induced stress and supporting both nutrient use efficiency and irrigation optimization decisions. The workflow also benchmarks Pix4Dmapper and Agisoft Metashape for UAV image processing, outlining their differences in georeferencing, data alignment, and output quality. Additionally, the study aims to develop sustainable agricultural practices that balance productivity with environmental responsibility by improving nitrogen use efficiency and reducing greenhouse gas emissions such as Nitrous oxide gas.