Discovery, The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences

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Several Authors

DISCOVERY

The Student Journal of Dale Bumpers College of Agricultural, Food and Life Sciences

Vol. 22 Fall 2021

UofA
DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

UNIVERSITY OF ARKANSAS
Dale Bumpers College of Agricultural, Food and Life Sciences

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Cover: Features the research of Bumpers student Evan Buckner, a crop science major, who studied plant pathology in soybeans. Evan and Dr. Rojas, his faculty mentor, discuss their research relationship on pages 5–6. Evan plans to continue his studies in a Ph.D. Program in the Department of Plant Pathology and Environmental Microbiology at Pennsylvania State University.

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Letter from the Dean

Deacue Fields

One of my favorite aspects of our college is that our students have a wide variety of careers they can pursue with a degree from the Dale Bumpers College of Agricultural, Food and Life Sciences.

Based on specific interests and passion, they can go in any number of directions to make a difference and impact the lives of many in the state, across the country, and beyond. Research offers a number of directions and options as well, depending on what questions you want to be answered and what problems you want to be solved. This year's issue of *Discovery*, our undergraduate journal, is a good illustration. Of the ten projects presented this year, eight different majors are represented.

As Dean of Bumpers College, it is encouraging and inspiring to see the issues tackled by our students as they strive to answer questions and address topics that have a far-reaching impact on society.

We are here to serve the people of Arkansas, across the country and around the world, and by tackling the subjects represented here, our students are doing just that. Our innovative programs, faculty experts, and outstanding students are improving the quality of life for everyone as graduates become scientists, innovators, managers, policymakers, entrepreneurs, educators, and most importantly—difference makers.

Our students are in the process of launching successful careers, conducting meaningful research, and sharing fact-based findings. *Discovery* highlights the efforts of just a few of them, along with their expert faculty mentors. Our faculty work with students to produce what you see here because they care about them and their development, as well as the research.

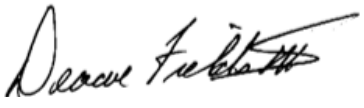
In this issue, you'll find projects by students and their mentors from the Department of Agricultural Economics and Agribusiness; the Department of Agricultural Education, Communications and Technology; the Department of Crop, Soil and Environmental Sciences; the Department of Poultry Science; and the human nutrition and dietetics, and human development and family sciences concentrations in our School of Human Environmental Sciences.

We encourage undergraduate research by awarding undergraduate research grants. Our students compete for research and travel grants awarded by the University of Arkansas Honors College and the Arkansas Department of Higher Education Student Undergraduate Research Fellowship grants program.

Projects may be designed to meet requirements for an honors project in the Bumpers College Honors Program. One of our goals is to prepare students to be responsible leaders with strong communication skills and problem-solving abilities. Inside this issue, you will find studies that highlight and exemplify those qualities in our student researchers and future leaders.

Congratulations to the student authors on completing your projects. And thank you to the faculty mentors and editors who worked with them to make this collection possible. As a college, we are pleased and proud to present their work in a citable publication as a service to them and our readers.

Deacue Fields, Dean
Dale Bumpers College of Agricultural, Food and Life Sciences



Letter from the Faculty Editor

Beth Kegley
Faculty Editor

This represents the third year that I have had the honor of serving as editor of this publication, and what a year it has been. I continue to be impressed with the broad scope of projects that students are conducting in the Dale Bumpers College of Agriculture, Food and Life Sciences, in conjunction with the University of Arkansas System Division of Agriculture's Arkansas Agricultural Experiment Station. But also impressive is the amount of perseverance and grit that was demonstrated this year by the students and their mentors as they continued to advance these research and creative projects through an unprecedented year of upheaval.

The students and faculty who are publishing these articles were also navigating the sudden change to remote learning in the spring of 2020 and the continued anxiety and turmoil of hybrid learning in the fall. Research labs were shut down completely or were operating but with very limited staffing and rules, which restricted undergraduate student access. Conferences, where students and faculty would have traveled to present their research findings, were canceled or accomplished virtually. Meetings with committees were done remotely, and it would have been very easy for these projects to be abandoned.

But that was not the case. All the faculty represented in these pages continued to take on this extra responsibility of mentoring these undergraduate students even though many were modifying courses and adapting to new teaching methods that they never imagined using. This publication signifies untold hours of commitment on the faculty's part: reviewing proposals, assisting with data collection, going through statistical analyses, and finally reading and rereading manuscripts. Their time and dedication to the students are deeply appreciated. It is this, in conjunction with each student's desire to persevere and accomplish these projects, that gives us this publication and the opportunity to discover the results of that work.

Beth Kegley, Faculty Editor, Discovery Journal and
Professor, Department of Animal Science

Featured Faculty Mentor and Student Explore the Dynamics of this Research Relationship

Every scientist can identify past interactions with passionate, patient mentors that fundamentally altered their career trajectory. At the Dale Bumpers College of Agricultural, Food and Life Sciences, the opportunity to interact with and inspire students at pivotal points in their lives happens in and outside of the classroom. As mentors, we have the possibility of positively impact students' futures by building skill sets and confidence. While mentoring students to conduct research in a lab setting, I personally try to focus on active learning involving the application of classroom concepts to real-world examples, which strongly reinforces the learning process. During this process, the students grasp the whole knowledge and application, and it naturally follows that they recognize their own potential to contribute to scientific progress in their field.

Dr. Alejandro Rojas
Faculty Mentor of
Evan Buckner

By helping students and mentoring them through the process, they think more critically and gain confidence in their potential to meaningfully participate in scientific research. My goal is to cultivate scientists who are thinking critically and actively evaluating the validity of scientific information with healthy skepticism. But, nowadays, it is also key to help students network and understand the social aspect of science. Students should realize that they are problem solvers, but it also involves effective communication and interaction with professionals from our field, other disciplines, and stakeholders.

Working with Evan was a great opportunity not only to have someone with multiple interests and help him identify those areas in which he could excel, but also to help him enter into disciplines identifying different experts that could also give him a wider view of the field. Evan was always looking for opportunities, and that active role of the student is also key for success. As mentor, I was able to channel his interest without limiting his interests in other areas. During his time, Evan was able to participate in different summer programs, and I was able to guide him during the process. It has been a great experience, and I am glad that Evan is now pursuing a Ph.D. in Plant Pathology.

Alejandro Rojas, Assistant Professor, University of Arkansas System Division of Agriculture's Department of Entomology and Plant Pathology

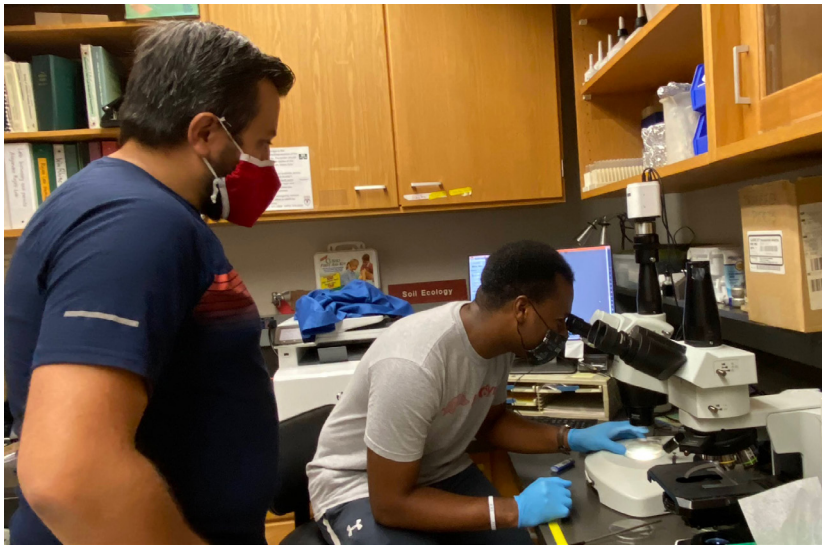
Featured Faculty Mentor and Student Explore the Dynamics of this Research Relationship

Evan Buckner
Bumpers Student

Undergraduate research is something that may go overlooked by some students during their time at a university. The wealth of knowledge and unsurpassable relationships formed during my time conducting undergraduate research in the Dale Bumpers College have been both a privilege and a learning experience. One of the things that I look back on is not just the end result but the journey it took to reach there. Researching under Dr. Alejandro Rojas in the Department of Entomology and Plant Pathology really exposed me to an endless world of plant pathogenic fungi, specifically the genus of fungi that I was matched to work on. It is amazing to now know that I can go out into cropping fields and identify the plant pathogens I studied and immediately go into an entire discussion on their morphology and how they interact with their hosts! Another benefit of this research journey is where it has landed me.

Plant pathology is such an intricate field not only in the research conducted but in the scientists that work within this discipline. In my sophomore year of college, I had the privilege to work with Dr. Rojas' former graduate school advisor, Dr. Chilvers, and it furthered my interest and curiosity for plant pathology! The culmination of working with Dr. Rojas and Dr. Childers, and a host of other experiences is what led me to apply and later be accepted into my graduate program for plant pathology. The research project I worked on with Dr. Rojas has opened not only my mind but my curiosity to more ways to control plant pathogens, and it is a curiosity I know will drive me to go and do the very best I can in my field.

Evan Buckner,
May 2021 Honors graduate in Crop Science



LAB WORK: Evan and his mentor Dr. Rojas, at the University of Arkansas System Division of Agriculture's Harry R. Rosen Alternative Pest Control Center, examining some of the isolations done from leaf plant material and looking at the spores to examine if they were successful in isolating *Cercospora*. Photo by Amber Lancaster.

Discovery on ScholarWorks@UARK

Journal management and submissions are facilitated through ScholarWorks@UARK, the institutional research repository for the University of Arkansas:

https://scholarworks.uark.edu/discoverymag/

Bumpers College undergraduate student research reaches a worldwide audience via this powerful database, with its extensive search engine and analytics, and ease in downloading individual articles. Here's a peek at readership distribution across the globe and most popular *Discovery* articles by download in recent months.

Table 1. Download history (top 10) for all *Discovery* issues from the period of 01 July 2020 to 30 June 2021.

Title	Downloads
Growth and Performance of Broiler Chicks During the Starter and Grower Phases in Phase-Feeding	1547
Love-bombing: A Narcissistic Approach to Relationship Formation	908
Soil Particle-Size Analysis: A Comparison of Two Methods	401
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Baseline Sensitivity to Demethylation Inhibitors Fungicides In *Cercospora* spp. and *Corynespora* spp. in Arkansas Soybeans

Meet the Student-Author

Evan Buckner

Evan processing Cercospora Leaf Blight symptomatic soybean tissue to induce sporulation of *Cercospora* spp. in a moist chamber for isolation.

Growing up in the delta region of Pine Bluff, Arkansas, and frequently visiting my family's farm in Winterville, Mississippi, I was always surrounded by agriculture. Whether it was visiting the family farm or just walking in my backyard, my passion for plants was growing rapidly. In high school, I had the opportunity to present at the southeast regional and state science fairs, where I was introduced to the State Soybean Science challenge, which awarded prizes to soybean-related projects. Through competing and placing in these competitions, I chose to apply to the University of Arkansas for crop sciences in Bumpers College. This program has helped me see not only my potential in agriculture but the far-reaching benefits of plant pathology research on communities, states, and nations. I've been privileged to participate in 3 research internships at Michigan and Kansas State Universities and presented research at several regional and national conferences. In addition, I received numerous awards, including the Deans and Chancellor's List, Travel Award to the Emerging Researchers National Conference in Washington, D.C., and most recently 1st place in the Division I Undergraduate Oral Presentation for the Minorities in Agriculture and Natural Resources and Related Sciences Conference. I plan to continue my studies in a Ph.D. Program in the Department of Plant Pathology and Environmental Microbiology at Pennsylvania State University. For continued mentorship, time, and dedication to this research project, I thank Drs. J. Alejandro Rojas and Martin J. Egan who have been a significant influence in my academic career.

Research at a Glance

- Target Spot, *Cercospora* Leaf Blight, and Frogeye Leafspot show varying signs of sensitivity to Demethylation Inhibitors (DMI).
- Target Spot is at greater risk for becoming resistant to DMI fungicides used and should be used in an integrated pest management (IPM) approach with other Fungicide Resistance Action Committee (FRAC) groups.
- Continual applications of the same amount of fungicide favor disease resistance in soybeans, and in addition to general IPM, field history, and previous infection of pathogens should also be taken into account.

Baseline Sensitivity to Demethylation Inhibitor Fungicides in *Cercospora* spp. and *Corynespora* spp. in Arkansas Soybeans

Evan Buckner* and Alejandro Rojas†

Abstract

Cercospora spp. and *Corynespora* spp. are two common foliar fungal pathogens in Arkansas and other soybean-producing areas. Two primary diseases caused by *Cercospora* spp. are Cercospora Leaf Blight (CLB, caused mainly by *C. kikuchii*) and Frogeye Leaf Spot (*C. sojina*). Over time, many fungicides used to combat these diseases have become ineffective as the pathogens have developed a resistance to them. The class of the fungicide in question is Triazoles [Demethylation Inhibitors (DMI)–FRAC 3]. Fifteen isolates consisting of *Corynespora cassiicola*, *Cercospora sojina*, and *Cercospora flagellaris* were tested to determine baseline sensitivities using serial dilutions (0, 0.01, 1, 10, 50 mg/L) of the fungicide Tilt (active ingredient: propiconazole). From the three species tested, *Corynespora cassiicola* (isolate 1601) showed the greatest EC_{50} value (10 mg/L). Sensitivity levels for *Cercospora sojina* were close to 1.00 mg/L, and EC_{50} were evenly distributed across all samples of this isolate. *Cercospora flagellaris* samples had the lowest EC_{50} values out of the three species tested as no growth was reported after 1 mg/L. Based on the results of this study, *C. cassiicola* is at greatest risk of resistance to the DMI fungicide Tilt, followed by *Cercospora sojina* and *C. flagellaris*, respectively.

* Evan Buckner is a May 2021 honors program graduate, with a major in Crop Science.
† Alejandro Rojas, the faculty mentor, is an Assistant Professor in the University of Arkansas System Division of Agriculture's Department of Entomology and Plant Pathology.

Introduction

The United States currently ranks number one in the world for soybean production, with one of the leading states, Arkansas, ranking 10th in the nation. Soybean pathogens in Arkansas currently cause yield losses up to 10% (USDA-NASS, 2017; Allen et al., 2017). Two of the primary diseases in soybean in Arkansas are Cercospora Leaf Blight (*Cercospora kikuchii*) and Frogeye Leaf Spot (*Cercospora sojina*). Cercospora Leaf Blight is also caused by the *Cercospora flagellaris* due to varying cercosporin production in *Cercospora* species (Albu et al., 2016; Cochran and Thiessen, 2021). The causal agent of Cercospora Leaf Blight also causes Purple Seed Stain in soybean. Cercospora Leaf Blight and Frogeye Leaf Spot are foliar fungal diseases usually occurring in the latter half of the growing season. These diseases usually originate from infected seeds or from diseased debris from a prior soybean crop. Favorable climates include warm and wet weather conditions. The initial symptoms of this disease cause a faint purple color on the upper surface of the leaf. Throughout the disease stages for Cercospora Leaf Blight, the color and texture may turn to leathery and dark purple, with bronze highlights. Similarly for Frogeye Leaf Spot, once these diseases have infected the plant, leaf spots with reddish to purple color and necrotic centers occur, and spots could coalesce causing more extensive damage. As the disease progresses, it results in defoliation around the upper canopy. The reduced number of leaves from the plant hinders the production of photosynthesis, ultimately killing the soybean crop (Albu et al., 2016; Faske et al., 2014; Crop Protection Network, 2021).

Corynespora cassiicola is an ascomycete pathogen in the order Pleosporales, first described by Berkeley and Curtis in 1868. This pathogen is common in the tropic regions and in greenhouses, also existing as a saprophyte or an endophyte, and as a pathogen infects over 500 species of plants (Schlub et al., 2009; MacKenzie et al., 2018). Symptoms of the pathogen can be present on the stems and leaves, showing the typical lesion in a target pattern and has been reported by some Arkansas farmers to have caused at least a 1.01 to 1.35 tons/ha loss of soybeans (Faske et al., 2014; Berkeley and Curtis, 1868).

In tropic regions, this disease has caused yield loss in the world's second-largest soybean-producing country, Brazil, and in Argentina. Target Spot in Brazil was first identified in 1976, and for many years, the disease was not a persistent pest (Molina et al., 2019). However, the usage of agronomic practices, such as continuous no till, can allow for the fungus to resurface (Molina et al., 2019).

Cercospora spp. (*C. flagellaris* and *C. sojina*) and *Corynespora cassiicola* cause significant harm to soybeans, with the latter being more widespread. Previous control of these fungal pathogens in the southern United States included fungicides within Fungicide Resistance Action Committee (FRAC) groups 11 (Quinone Outside Inhibitors (QoI)), 1 (Benzimidizole (MBC)), and 3 (Demethylation Inhibitors (DMI)). With continuous use of fungicides in FRAC group 3, there is a threat of future fungicide resistance in *Cercospora* spp. and *Corynespora* to the chemical family propiconazole. The primary objective of this research was to determine fungicide resistance levels in *Cercospora*. spp. (*C. flagellaris* and *C. sojina*) and *Corynespora cassiicola* when challenged with the fungicide propiconazole (Faske et al., 2014; Almeida et al., 1976; Avozani, 2011; Rojas, pers. comm., January 2020).

Materials and Methods

Foliage samples were collected during the fall semester of 2019 from fields exhibiting symptoms associated with *Cercospora flagellaris*, *Cercospora sojina*, and *Corynespora cassiicola*. Plant tissue samples were collected from four Arkansas locations, the University of Arkansas System Division of Agriculture's Vegetable Research Station, Kibler; the Lon Mann Cotton Research Station, Marianna; the Jackson County Extension Center, Newport; and the Rohwer Research Station, Rohwer. Sample collection was limited to the time in the planting season in which the fungi heavily infect and reproduce on the soybean plants.

The initial step was to collect a minimum of 10 to 15 infected foliage/leaf samples from each location and place them in sealed plastic bags (Ziploc) for each separate location and for each pathogen. A minimum of 10 to 15 infected pods (to identify infected seeds) was taken from infected plants. Once the leaves and seeds were collected, fungal isolations were conducted to generate spores from infected tissue. For fungal isolations, moist chambers were set up using a moist towel paper placed at the bottom of a 0.102 × 0.102 × 0.305-m plastic container, and leaves were placed inside and sealed. Containers were incubated at room temperature for 48 hours, tracking spore development twice daily. After this, in a secure biological hood, growth from leaf samples was taken from plastic containers, and specimens with abundant fungal growth were chosen for plating. A metal needle was used to lightly scrape the surface of the infected leaf area and then was poked into potato dextrose agar (PDA). Spores were picked using a needle and transferred to PDA with antibiotics (Danitol, ampicillin, streptomycin, and rifampicin). Another method performed was taking a scraper with a circular end and wrapping the fungal growth around it by rubbing the scraper in a round pattern on the leaf surfaces; then the scraper was rubbed on the PDA. If the same metal scraper was used for multiple extractions, then close attention was paid to disinfect it of unwanted fungi by placing the needle in an open flame followed by rinsing with ethanol (70%).

Seed isolates from pods (for growing purple seed stain (*Cercospora flagellaris*)) were recovered directly from seed

after sterilizing the seeds in 70% ethanol and drying them in a sterile laminar flow hood. Seeds were plated on PDA media plus antibiotics (Danitol, ampicillin, streptomycin, and rifampicin), and plates were incubated at room temperature for 4 to 7 days (Cochran et al., 2021). Media plates with antibiotics were placed in sealed plastic containers until fungi reached growth in diameter of 40 to 50 mm. The specified growth allows for ample sample collection for fungicide trials. In addition to plates in the container, 3 mothballs in a paper slip were placed in the containers to minimize mite contamination.

After fungal growth reached a colony of roughly 40 mm, plugs were taken and transferred to fungicide-amended plates and an unamended control plate. Three replications each for treatment level of 0, 0.01. 0.1, 1, 10, and 50 mg/L of DMI fungicide were prepared. For each isolate of each pathogen tested, there were 3 replications for each of the treatment levels totaling 18 total plates per isolate. Potato Dextrose Agar was the base of the media, with corresponding treatment levels added for final levels of the fungicide concentrations. Each of these levels was used for the DMI fungicide for each of the 3 isolates, *C. flagellaris*, *C. sojina*, and *C. cassiicola*. A 5-mm diameter metal corkborer was pushed around the media to extract 18 separate plugs. Each fungal sample was placed on the media with the separate fungicide mixtures and allowed to grow over a period of 7 days. No antibiotics were used in addition to the fungicide media plates. Plates were placed in sealed plastic containers away from windows and incubated at room temperature, after which growth was measured in mm using a digital caliper of the colony in two perpendicular directions and averaged for analysis. Growth was recorded in a spreadsheet in Microsoft Excel and analyzed through R Studio using R (Desktop 1.4.1106) using the package EZEC and drc (R Core Team, 2018; Ritz et al., 2015; Kamvar, 2014).

Results and Discussion

Two possible threats to the validity of this research project were incorrect fungal identification and contamination on the Petri dish plates from non-targeted fungi. These threats, in conjunction with the primary steps of the project, were key to understanding the resistance levels and stable population collections of the fungi involved. For this project, we used a quantitative experimental design because this research project dealt primarily with numeric levels of potency for FRAC group 3. For fungal identification, polymerase chain reaction (PCR) was used to amplify DNA of our samples and determine if they had the same number of base pairs as known samples of *Cercospora* spp. and *Corynespora* spp. The second concern for validation came from potential contamination of the Petri dish plates on which the fungi were grown and fungicide was applied. In

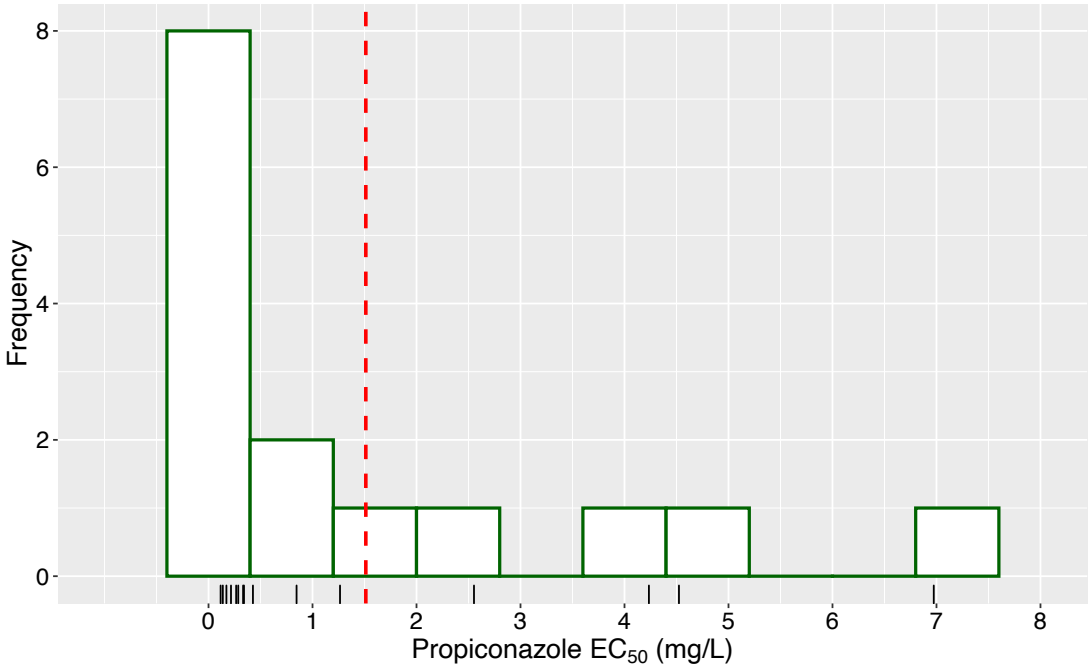

Fig. 1. Effective Concentration of propiconazole that inhibits at least 50% of the fungal growth for 15 isolates of *Cercospora* spp. and *Corynespora cassiicola* in Arkansas Soybeans. The dashed red line represents the mean of all EC_{50} values for the entire sample population.

the laboratory, thousands of other fungi spores are present and could land on Petri dishes being prepped, causing unwanted growth. The threats mentioned were factors viewed in a study by Xavier et al. (2013) on baseline sensitivities to *Corynespora* spp.

A total of 15 isolates were used in this study. Three isolates were *C. flagellaris*, 6 were *C. cassiicola*, and 6 were *C. sojina*. For DMI, all isolates were completely inhibited at 50 mg/L. The greatest number of isolates inhibited by the fungicide had EC_{50} values ranging from 1 to 10 mg/L (Fig. 1).

Effective Concentration values for 50% fungal inhibition were inconsistent across the three species. However, greater EC_{50} values were associated with *Corynespora cassiicola* compared with EC_{50} values obtained for *Cercospora sojina* and *Cercospora flagellaris*. In addition to greater EC_{50} values, there were some abnormal distributions of isolates regarding growth over time. This abnormality was observed as plates with low concentrations (0.01 and 1 mg/L) of fungicide having a larger percentage of growth than plates with other concentrations of fungicide. For all 6 isolates of the *C. cassiicola*, isolate 1601 was the only one to show this abnormal growth between 0 and 1 mg/L (Fig. 2); this phenomenon is known as the hormetic effect since some isolates could respond with an increased growth under sublethal concentrations of fungicides (Pradham et al., 2017).

The EC_{50} values for the Frogeye Leaf Spot were less than *C. cassiicola* as the value was close to 1.00 mg/L but no greater than 10.00 mg/L. This relationship shows the higher levels of sensitivities of *C. sojina* isolates compared to *C. cassiicola*. Isolates for this pathogen represented even distribution for all treatments (Fig. 3).

Effective Concentration value for 50% fungal inhibition was the least for the Cercospora Leaf Blight isolates. No inhibition was reported at greater than 1 mg/L, and all isolate growth was distributed across the ranges tested without abnormality (hormetic effect) in percent growth. Isolates used for this fungal genus were *C. flagellaris,* and it is associated with the lineage of Cercospora Leaf Blight (Albu et al., 2016). Cercospora Leaf Blight is associated with Purple Seed Stain, and *C. kikuchii* and *flagellaris* have been linked in lineage to several other *Cercospora* diseases in soybean- growing regions (Albu et al., 2016; Price et al., 2015). Cercospora Leaf Blight isolates represented a sigmoidal distribution for all treatments. There was a steady decrease in the percent growth for the increasing concentrations (mg/L) of the fungicide, which also represents the current sensitivity levels of these isolates to propiconazole, and EC_{50} values were overall below 1 mg/L in comparison to *C. cassiicola,* which was greater than 1 mg/L. Growth decline was steeper than *C. sojina* and *C. cassiicola* (Fig. 4).

Conclusions

Of the three fungal species tested, no cross-resistance was reported as multiple FRAC 3 fungicides were not test-

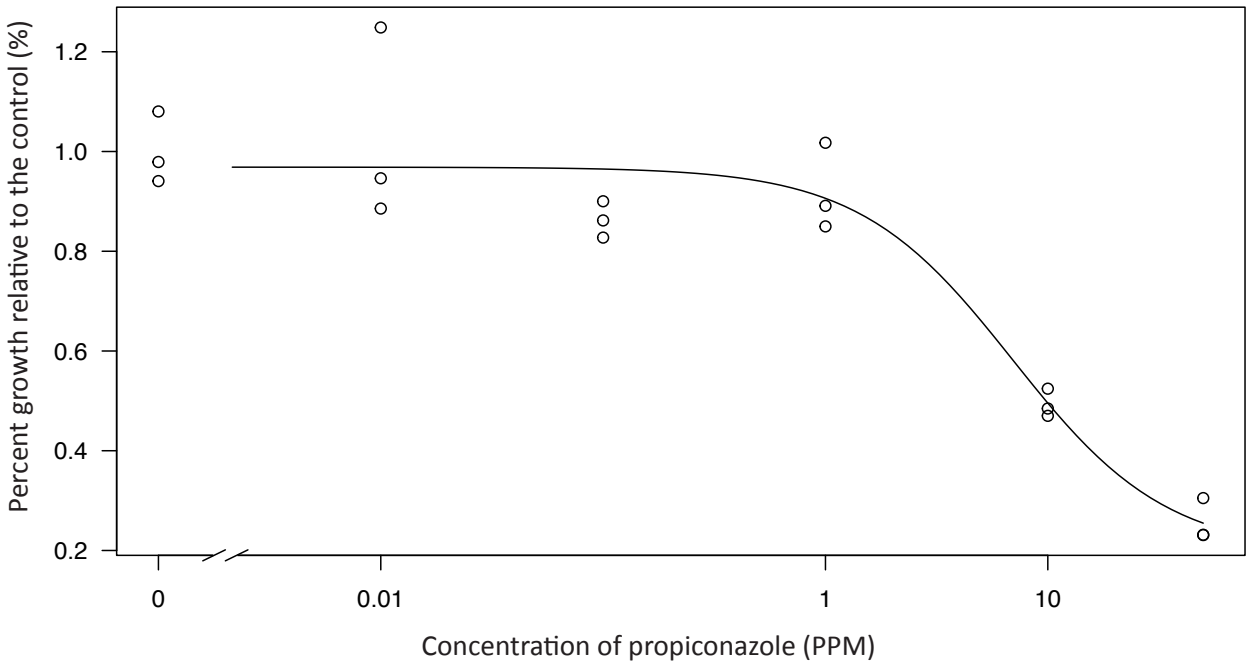

Fig. 2. Distribution of EC_{50} values for *C. cassiicola* isolates 1601. With percent growth on the *y*-axis, the EC_{50} value for isolate 1601 fell in the range of 10.00 mg/L (ppm).

ed. However, varying sensitivity levels to the fungicide for all species may prove a future concern to growers as similar chemical control practices may continue to be in place. *Corynespora cassiicola* had the greatest EC_{50} values indicating a sensitivity lower than the latter two species. This may also point to the growing tolerance of this pathogen to DMI fungicides, and that resistance may be reached earlier in *Corynespora* spp. In addition, there were differences in sensitivity values between isolates of the same fungal species. This difference in sensitivity values may be attributed to local adaptation under different fungicide exposures under different management programs. In comparing the two *Cercospora* species, *C. sojina* had greater EC_{50} values and is at a larger risk of developing resistance than *C. flagellaris*. An integrated pest management regime in conjunction with the integrated FRAC chemistries is the current recommendation of this research project to aid in decreased disease resistance.

Acknowledgments

E. Buckner would like to thank the University of Arkansas Bumpers Honors Program and the Arkansas Louis Stokes Alliance for Minority Participation for support and funding of this research project. Both authors would like to acknowledge support provided by the Arkansas Biosciences Institute, the major research component of the Arkansas Tobacco Settlement Proceeds Act of 2000.

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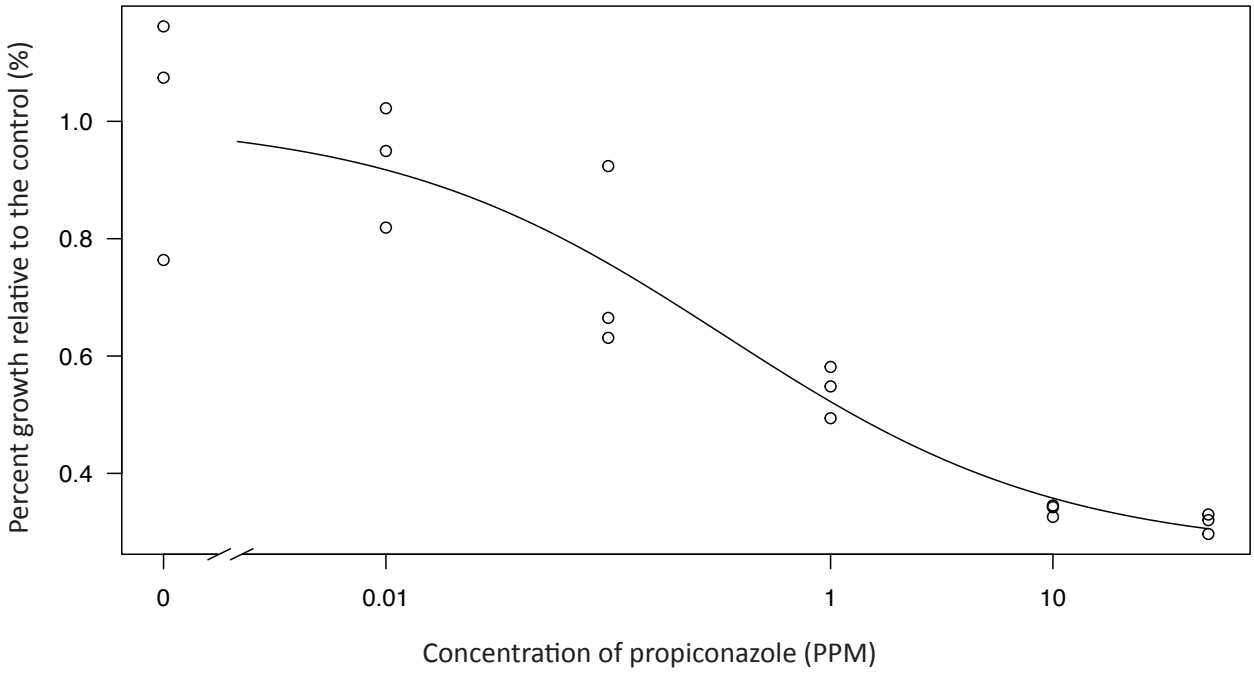

Fig. 3. Distribution of EC_{50} values for *C. sojina* isolate hSB-421.

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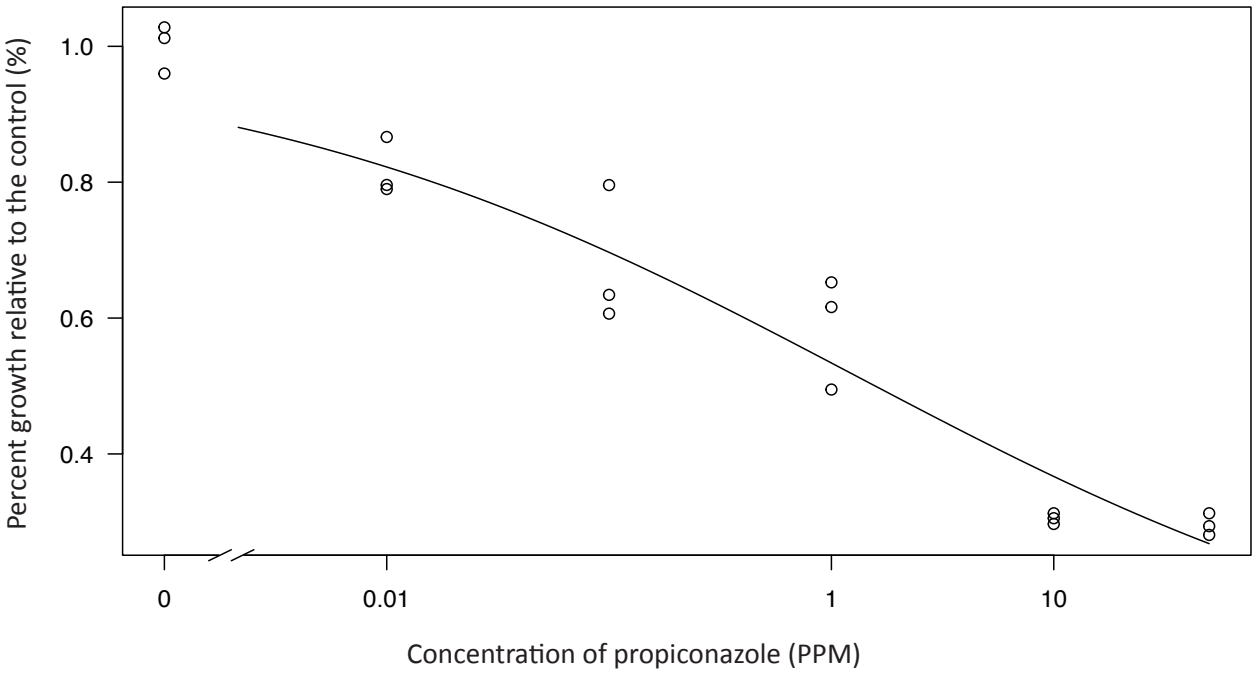

Fig. 4. Distribution of EC_{50} values for *Cercospora flagellaris* isolate 1901.

Creating a Culturally Competent Children's Library

Meet the Student-Author

Rachel Burger

Rachel reading to a student in the culturally competent library space at the Bumpers College Jean Tyson Child Development Study Center.

Ever since I was young, I have had a passion for reading. My parents sat at my bedside while I begged them to read me another story before bedtime. I spent summers going to the library to pick out books that I would spend entire days reading. Books have brought me much comfort and happiness over the years and taught me things I never imagined possible. It brings me joy to have been able to give the opportunity to grow a similar love for reading in young children through the creation of a culturally competent library. Living in a foreign country and having a Bachelor of Arts in Spanish, has made bilingualism and linguistics of significant importance to me. I love having the opportunity to introduce children to foreign languages at an early age. Thanks to my professor, Dr. Jacquelyn Mosley, the topic of cultural competence has become a new interest of mine. I am grateful to be able to spark the interest in other cultures and languages in the children and educators at this child development center.

As a future Certified Child Life Specialist, I hope to apply the knowledge and skills gained through the implementation of my creative project to helping children and families in a hospital setting. I am immensely thankful to my advisor and mentor Donia Timby. Without her this project would not have been possible. I would also like to thank the rest of my committee members Dr. Jacquelyn Mosley, Dr. Laura Herold, and Dr. Shelley McNally, as well as educators Caitlyn Daniels and Lori Harris who assisted with the transformation of the library space. Thanks to their help and hard work, this group of children have access to a safe and comfortable space in which they can explore new cultures and languages.

Research at a Glance

- There is a growing need for well-rounded educations that include cultural competence and diversity, equity, and inclusion efforts, especially when it comes to young children. One of the best ways to teach cultural competence to children is through the use of books.
- Introducing new cultures and languages to children at an early age will give them a tremendous head start. It will normalize topics such as race/ethnicity, language, and religion, and hopefully help to prevent things like color blindness, bias, or stereotypes.
- A culturally competent and linguistically inclusive library space at a child development center will give children opportunities to explore their own cultures, other cultures around the world, and new foreign languages in a safe and friendly environment.

Creating a Culturally Competent Children's Library

Rachel Burger,[*] *Donia Timby,*[†] *Jacquelyn D. Wiersma-Mosley,*[§] *Laura Herold,*[‡] *and Shelley McNally*[¶]

Abstract

There is an ever-growing need for cultural competence and a well-rounded education, especially for children. In order to promote cultural competence, this creative project focused on enhancing a library space at the University of Arkansas Bumpers College Jean Tyson Child Development Study Center, Fayetteville, Arkansas with resources that address diversity and cultural competence. The goal was to transform the library into an enticing, relaxing, and judgment-free area where children feel comfortable to explore their culture and the cultures of others. New books added to the library were thoroughly reviewed and chosen for the purpose of promoting cultural competence and inclusion, as well as new language introduction. A wide variety of cultures from around the world, as well as over ten languages, were represented in the new reading materials. In addition to new reading materials, new furniture and decor items were also purchased to elevate the space into a comfortable area that welcomes children and invites them to explore. The hope is that in using the new space and reading books that focus on cultural competence, the children (and adult educators) will learn about different cultures.

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[¶] Dr. Shelley McNally is the Director of the Jean Tyson Child Development Study Center.

Introduction

Just as racism is a learned construct, cultural competence is something that is learned over time and made up of inner reflection and awareness (Young and Guo, 2020). There is a need to focus more on learning about different cultures around the world and how to best interact with people who are different. All people deserve to be treated with respect regardless of where they were born, their culture, their religion, their appearance, their sexual orientation, their ability level, or other intersectional identities (Lalljee et al., 2009).

One of the best mediums to teach cultural competence is through books, especially when it comes to children. Books are a great way to develop language and introduce new topics such as different cultures and other languages to young children. Combining books, new languages, and, most importantly, topics of cultural competence are ways to foster the desire for learning, education, and human connection. Introducing new cultures and languages to children at an early age will give them a tremendous head start. It will normalize topics such as race/ethnicity, language, and even religion, and hopefully help to prevent things like color blindness, bias, or stereotypes. Through creating a library that focuses on cultural competence and foreign languages, children will be exposed to topics of diversity, equity, and inclusion, which in turn may help these children grow into more respectful adults who are accepting of other people and other ways of life. The library space will give them opportunities to explore their own cultures, other cultures around the world, and new foreign languages in a safe and friendly environment.

Cultural competence is an ongoing, multidimensional construct made up of knowledge, awareness, and skills that encompass beliefs that people should recognize as well as appreciate other cultural groups and be able to interact effectively with them (Benuto et al., 2018). It is "the process by which individuals and systems respond respectfully and effectively to people of all cultures, languages, classes, races, ethnic backgrounds, religions, spiritual traditions, immigration status, and other diversity factors in a manner that recognizes, affirms, values, and preserves their dignity" (Danso, 2018). The need for cultural competence in professional fields such as child and human services is

Fig. 1. The selection of 145 newly purchased books for the culturally competent children's library at the University of Arkansas Bumpers College Jean Tyson Child Development Study Center.

becoming quite evident (Danso, 2018), but the need for it in education and literacy is largely unstudied.

There may be a positive relationship between experiences with early literacy and language, and academic outcomes. However, there is still a lack of libraries and literacy programs offered to children below the age of three, especially as it relates to cultural competence. Reading with children at an early age is one of the most crucial activities for development. There is much research that supports the idea that reading to children at an early age expands a child's vocabulary. All data support the efficacy of using reading as a way to promote the development of vocabulary in children (Farrant and Zubrick, 2012). In addition to promoting language development and positively impacting children's academic skills, reading can lead to increased bonding between the adult and child and helps facilitate curiosity and a desire to learn.

Materials and Methods

While the overall aesthetic of the library was important, the main focus was primarily the new culturally competent and linguistically inclusive books. An extensive amount of research was done to be able to ensure that the materials truly did promote cultural competence and inclusivity. In the initial process of researching potential books, a website titled socialjusticebooks.com was utilized to help with the book selection process. The website is catered towards children of all ages and educators and features carefully selected lists of books that promote social justice issues. Using the recommended lists of books on this website as a guideline, books that appeared to meet the goals of the culturally competent library were further identified. In the end, 145 new books were purchased for the library (See Fig. 1).

An attempt was made to select books that represent a wide variety of cultures, religions, traditions, holidays, lifestyles, languages, and ability levels. The languages represented in the books that were selected included: English, Spanish, French, Italian, German, Swiss-German, Mandarin, Japanese, Russian, Turkish, Farsi, Hindu, Arabic, Hausa, Haitian Creole, American Sign Language, and Anishinaabemowin, which is the language of the Anishinaabe nation—an indigenous group native to the northern United States and parts of Canada (Noodin, 2014). This adds up to a total of 15 languages included in the new reading materials.

Fig. 2. The books that were suspended from the ceiling in the culturally competent children's library at the University of Arkansas Bumpers College Jean Tyson Child Development Study Center.

Due to the limited amount of child-sized furniture and comfortable reading spaces, new furniture and decor were also necessities. Each piece of furniture was chosen with not only comfort and appearance in mind, but also with the goal of being accessible for all the children regardless of developmental levels and physical capabilities. These furniture selections were made to provide a large selection of seating areas so that each child could choose to sit on a seat or relax on the floor as they read. In addition to the actual furniture, a dollhouse and an activity table were included so that the library was more versatile. A total of 15 wooden dolls were ordered, consisting of 3 different races/ethnicities.

Much thought and planning went into every step of the layout process for the culturally competent library. Every area is safe and accessible for all of the children, with certain areas designed with a specific age group in mind. With infants in mind, a rug, one bookshelf, a bench, and the two pouf ottomans were placed in front of a large mirror. There are also several coiled rope baskets in this area filled with books for easier access and to allow the infants more autonomy by giving them the opportunity to place them in the baskets themselves since that is easier than restocking them on the shelves. In a similar manner, another reading space was set up in the back corner of the room next to large windows. A pre-existing couch and tent were also placed in this space designed for older toddlers and preschoolers. Like in the infant area, children using this space can decide to lay on the soft rug to read or one of the available seating options. Next to this space is a magazine rack featuring magazines and informational pamphlets. Above the magazine rack hangs a pegboard displaying plant propagations in glass jars.

In order to be even more inclusive of each age group and developmental level, three child-sized tables of varying heights were placed in the aligning corners of the shelves. The purpose of the tables is to provide a space for children to sit and draw/write. Each table includes chairs and materials that are specific to either infants, toddlers, or preschoolers. With the dollhouse in its own secluded spot, the children have the opportunity to use this cozy area to participate in active storytelling. Tucking the dollhouse in a nook encourages quiet as opposed to loud play while in the library, just as placing the activity table to the side of the room does.

Lastly, the most wonderful addition to the library space was the circular, rotating bookshelf. The shelf features all books written in several languages. These books were randomly organized with hopes that a different language would

Fig. 3. The plants that were suspended from the ceiling in the culturally competent children's library at the University of Arkansas Bumpers College Jean Tyson Child Development Study Center.

be selected each time a book is chosen. All of the board books and smaller sized books are on the bottom level of the bookshelf so that they are more easily accessible to infants. For added visual stimulus, books that had internal damage and were going to be thrown away were hung from the ceiling using clear string, and three plants were hung in the back of the room (shown in Figs. 2, 3, and 4).

Results and Discussion

Overall, the library was designed with the intention of being a fun space for children to enjoy. There is something in the library for every child regardless of their age, developmental level, physical capabilities, or temperaments. The goal of this creative project was to enhance the previous library space into a new, fully formed early childhood library that is culturally competent and linguistically inclusive. The current project expands on a study that focused on how to introduce intercultural competence into early childhood education programs and how it is currently exhibited (Fanous et al., 2020). Fanous' project conducted intercultural competence training with several early childhood educators and staff members at a childcare center, discovering that training and conversation can foster growth in an educator's cultural competence. However, there is still a need for more research surrounding cultural competence, especially how it relates to young children.

Research has found that developmentally appropriate spaces can help promote growth and development as well as create a more respectful environment (Minzenberg et al., 1999). A dollhouse was chosen for the purpose of active storytelling, which provides children the opportunity

Fig. 4. The view of the finished space from the back of the culturally competent children's library at the University of Arkansas Bumpers College Jean Tyson Child Development Study Center.

for alternative communication (Jorgensen and Strand, 2014). Using toys and materials to participate in active storytelling allows children to act out stories and put their imaginations to use in an interactive way (Jorgensen and Strand, 2014).

One of the overall goals for this creative project was for children to develop an interest in not only reading, but also a genuine interest in learning about the world around them, and most importantly the people around them. According to the phenomenon known as homophily, people are more likely to migrate towards and interact with other people who are similar to themselves (Boucher, 2015). This means that as the children are growing up and later as adults, their social circles will likely be made up of other people who look like them and are of similar backgrounds. Only interacting with people of similar characteristics makes cultural competence less likely. Interacting with people of different races/ethnicities, socioeconomic status, lifestyles, religions, and other differences allows people the opportunity to learn more about them on a personal level.

This culturally competent library exposes these children early on to different cultures, ways of life, and languages. Perhaps, these children will grow up with a greater appreciation for people that are different from them, instead of fearing the unknown, avoiding people that are different from them, and thinking that there are either too many differences or too many similarities between people. The larger goal is that these children will have respect for other people and their cultures and even become advocates for those in need.

Cultural competence can help young children learn to be accepting of others. The earlier that these topics are introduced, the more normalized they are going to be. By reading books such as Mommy's Khimar, Under My Hijab, and Crescent Moons and Pointed Minarets that introduce Islamism and hijabs to a child will teach them that it is okay to have different beliefs and to not be afraid of people who choose to cover their hair and/or faces with a scarf. By reading books such as Princess Hair and Black, White, Just Right that embraces all hair types, not just "white hair," it may become more acceptable for black people to wear their hair naturally in the workplace and not be deemed unprofessional. The books in different languages will introduce languages to children that they may not have ever had the opportunity to see before, which could possibly foster an interest in other languages. These resources encourage others to learn a second or even a third or fourth language. For the children who come from bilingual/multilingual homes, the books in their home languages may foster a desire to continue learning their home language and hopefully further connect with their families.

Conclusions

In conclusion, the goal of this project was to introduce cultural competence to lead children on a path towards respect and acceptance of others. Each book was carefully chosen to serve the specific purpose of education and normalization. The space was designed with comfortability, appearance, and, most of all, accessibility in mind.

Acknowledgments

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Willingness-to-Pay for Halal and Branded Poultry in Northern Mozambique

Meet the Student-Author

Alison Creasey

I am a May 2021 graduate with a degree in Agricultural Education, Communications and Technology. I filled my time at the University of Arkansas with being active inside and out of the classroom. I was a member of Chi Omega, The Agricultural Communicators of Tomorrow, and served as an Associated Student Government agent. I also served as an office on the Bumpers Honors Student Board. I volunteered with Potter's House for two years and was active in the Fellowship Fayetteville college ministry. Along with leadership and service, I worked part-time for the university for two years in the Agricultural Education, Communications and Technology (AECT) department. As a communications specialist in the Experiential Learning Lab, I helped write departmental newsletters and created promotional materials for the Don Tyson Center for Agricultural Sciences. The AECT department has been a place of personal and professional growth over the course of my time as a student, and I am so thankful to have been able to call this department home. I want to extend my deepest gratitude to my honors mentor, Dr. Nalley, and my thesis committee members, Dr. Farmer and Dr. Miller. They all played such an integral role in shaping my college career, and I am so grateful for the mentorship and guidance they provided to me.

Alison Creasey with the marketing team and translator in Mozambique.

Research at a Glance

- Large-scale domestic poultry industries are relatively new in Mozambique; brand loyalty is a new concept that has not been empirically analyzed before in the literature.
- In communities like Nampula, branding could be a proxy for food safety concerns; in many low-income countries, commodities have no branding associated with them.
- Even in the poorest part of Mozambique, Muslims are willing to pay a premium for Halal-produced meat.

Willingness-to-Pay for Halal and Branded Poultry in Northern Mozambique

Alison Creasey[*] *and Lawton Lanier Nalley*[†]

Abstract

While price typically drives consumers' food-purchasing decisions in low-income countries, religious attributes associated with food production and corporate branding could influence buying patterns. In Mozambique, more than 46% of people were living below the poverty line of ($0.31 USD) per day in 2018. That being said, in the Nampula Province (the location of this study), which is the second poorest province in the country, over 25% of the population is Muslim and may be willing-to-pay (WTP) a premium for Halal meat products to uphold Islamic beliefs. Like many parts of sub-Saharan Africa, poultry is the fastest-growing source of protein. Since large-scale domestic poultry industries are relatively new in Mozambique, brand loyalty is a new concept that has not been empirically analyzed before in the literature. In this study, we surveyed 312 consumers in Nampula, Mozambique, using a choice-based modeling approach to estimate if consumers were WTP for chicken that was slaughtered according to Halal laws and chicken which was branded by New Horizons (the largest chicken producer in Nampula). Results from the small sample in this study indicated that even in low-income countries like Mozambique, consumers are WTP a premium for branding. Specifically, Muslim consumers were WTP a premium for Halal-produced meat with branding. While non-Muslims did associate Halal poultry with being safer (69%) and of better quality (64%), but they were not found to be WTP a premium for these attributes.

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[†] Lawton Lanier Nalley, the faculty mentor, is a professor in the Department of Agricultural Economics and Agribusiness.

Introduction

Mozambique has consistently battled poverty and food insecurity since its independence from Portugal in 1975. Despite governmental efforts to combat food insecurity and stimulate economic growth, Mozambique has continued to rank among the lowest in the world for per-capita gross domestic product at $1,300 (CIA, 2018). In holistic measurements of livelihoods, like the Human Development Index, Mozambique ranked 181 out of 188 countries in 2016 (UNDP, 2016).

While the availability of poultry in Northern Mozambique has been cited as one way to combat food insecurity, specifically pertaining to protein deficiencies (FAO, 2013), under Islamic law, 27% of Mozambique is estimated to be Muslim, meaning meat must be slaughtered in the Halal tradition, which can cause production constraints. While not a barrier to food security, Halal slaughtering could be seen as an impediment to achieving efficiency in food production.

According to the United Nations Food and Agricultural Organization (FAO), the definition of Halal foods is foods permitted under the Islamic Law and the following conditions: does not consist of or contain anything which is considered to be unlawful to Islamic Law; has not been prepared, processed, transported, or stored using any appliance or facility that was not free from anything unlawful according to Islamic Law; and has not in the course of preparation, processing, transportation, or storage been in contact with any food that fails to satisfy the previously stated conditions (FAO, 1997). When battling food insecurity and protein deficiencies, these rules could pose a high cost for non-Halal producing protein facilities to produce both Halal and non-Halal foods.

Branding for commodities, and specifically meat products, in open-air African markets is still in its infancy due to lack of copyright law, lack of labeling, lack of monitoring and enforcement, and lack of large-scale meat processors. The majority of rural Africans often find themselves searching for the cheapest food possible as the majority of their income goes to food purchases. This idea imposes an important question: are people willing to pay (WTP) for branded commodity products? Given that there is a lack of food safety enforcement in Mozambique, such as the Food and Drug Administration (FDA) in the United States, branded food could serve as a proxy for food safety, playing the role of educating consumers on where their food comes from and how it was made.

The objective of this study was first to determine if consumers (both Muslims and non-Muslims) are WTP a premium for Halal-produced chicken. In high-income countries where the majority of the household budget does not go to food purchases, the expectation is that Muslims would be WTP a premium. In low-income countries where consumers are typically trying to minimize cost, this may not be the case. If it is found that non-Muslims are WTP a premium for Halal, it may signal to meat processors that Halal can proxy for food safety or quality. Second, this study attempted to determine if low-income consumers in Mozambique would be WTP a premium for a branded poultry product. As there is no FDA in Mozambique and very little food safety regulation, branding may again be a proxy for food safety. Given the recent growth of the poultry sector across Africa, processors must determine if it is worth investing in branding their product through marketing and slaughtering according to Halal rules. This study, while myopic to Northern Mozambique, provides a methodology that could be replicated across Africa to help answer these important questions regarding marketing on both brand and Halal production.

Materials and Methods

Over the course of two weeks in May of 2019, 312 people in Nampula, Mozambique, were surveyed on their buying preferences of whole frozen chickens. Questions were broken up into 12 possible buying options and labeling combinations. For each response, questions were randomized, so respondents were shown 6 different questions containing buying options. Information presented to survey participants included a control (with only a picture of a frozen chicken), a choice of chicken slaughtered in a Halal manner, and a choice of chicken produced by New Horizons (NH), which in this case was our branded option. Thus, participants had two information sets broken up into 4 possible combinations for purchasing a frozen chicken (halal only, NH only, halal and NH, and the control). Three different pricing options were associated with each of the four possible purchasing options above. These prices were chosen by current price averages of processed chicken at the time of the study. These prices were 165 Mozambican metical (MZN), 195 MZN, and 225 MZN for a 2-kg frozen chicken.

Figure 1 illustrates 3 of the possible 12 choices with which a consumer was presented. These choices were randomized such that each consumer was presented with a different choice set. Participants were shown three options at one time and asked to choose which one they preferred. While the three buying options were randomized between the 12 total options, participants were always given a "no buy" option to opt-out of choosing between the three options presented. Participants were shown a total of 6 choice sets (which included three buying options) before completion of the experiment.

The survey was offered in two languages: English and Portuguese. Along with six choice-based questions (Fig.

1), two questions were asked to obtain the respondents' demographic information: one regarding the respondents' age and one asking which religion the respondent identifies with (Christian, Muslim, or other). Frozen, processed chicken is most often sold as the whole bird, indicated by the image shown in the survey. The New Horizons logo used in the survey was provided by a representative of the company. The Halal logo shown in the survey is the official Halal logo for the Mozambique Muslim Commission.

After the choice-based experiment was completed, several questions were asked pertaining to buying habits of frozen poultry in Mozambique. The first question asked about which religion each participant practiced; this was asked to determine if the respondents' religion had an effect on their buying preferences, given that Muslims are only supposed to eat Halal meat. It was then asked if the respondent thinks that Halal meat is safer than non-Halal meat. This question was asked because it was originally hypothesized that Halal meat could be a proxy for food safety for people even if they do not practice Islam. Respondents were then asked if they thought that Halal meat was of better quality than non-Halal meat. It was also hypothesized that Halal branding could serve as a proxy for higher quality meat for some people.

A random parameters logit (RPL) model was estimated using simulated maximum-likelihood techniques, where an individual's utility for a given poultry alternative is a function of the alternative's attributes and their price levels. The alternative specific constant (ASC) in the model is the "no buy option." In this case, mean utility parameters and their standard deviations are estimated for Price, "New Horizons Brand," "Halal," the interaction between "Halal" and a respondent being Muslim, and "No Buy." The interaction between Muslim and Halal was warranted given the possible compounding effect of the

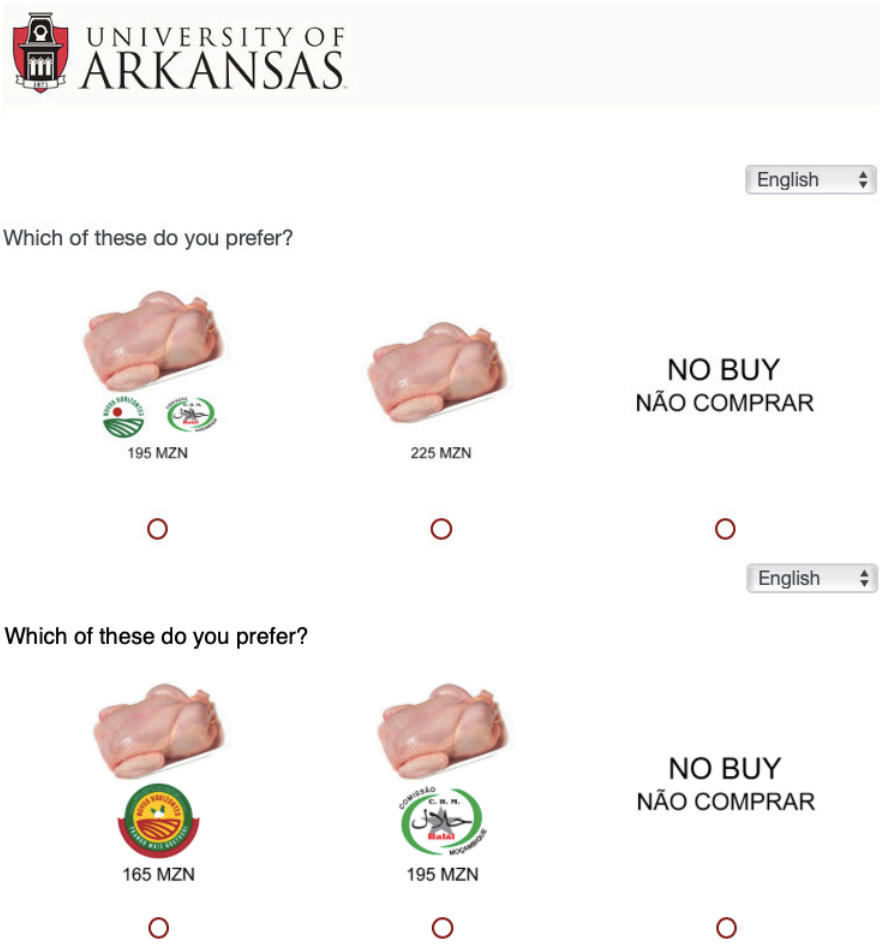

Fig. 1. Four product choices (halal only, branded halal, branded only, and non-branded) for 2-kg frozen chicken with 3 random pricing alternatives a producer could either opt to purchase or not in a repeated choice-based experiment with two information sets.

two independent variables. Marginal WTP values were then computed by dividing each mean parameter by the negative of the price coefficient.

Results and Discussion

Muslim respondents hold Halal meat in higher regard than non-Muslim respondents in relation to safety and quality (Table 1). Of all respondents, 69% thought that Halal meat was safer than non-Halal meat and 64% of all respondents thought that Halal meat was of better quality than non-Halal meat. When looking at the subsample by religion, not surprisingly, a greater percentage of Muslim participants thought that Halal meat was of better quality (85%) and was safer than non-Halal meat (92%). It should be noted that this experiment took place during the month of Ramadan, which could have biased these responses.

In the RPL Model (Table 2), importantly, the coefficient for Price was significant ($P < 0.001$) and negative as the theory predicts, which would imply that consumers were acting rationally and the law of demand holds. While this result seems intuitive, it is an important check to ensure that participants understood the survey, paid attention to the survey options, and comprehended alternative choice sets throughout the survey.

Marginal WTP (Table 2) indicates that people, on average, were WTP a premium of 40.51 MZN ($0.55 USD) for the New Horizons Brand poultry ($P < 0.05$). This is 20.7% greater than the average price (195 MZN) of the 2-kg frozen chicken in the survey. This finding was significant as it suggests that at least in the frozen poultry market in Nampula, branding has an effect on WTP. While the drivers of this premium were outside the scope of this study, some assumptions can be drawn. First, New Horizons was a large employer in the Nampula region,

Table 1. Results of supplemental questions.

Questions	All respondents	Muslim respondents	Christian and other respondents
Do you usually buy live or processed chicken?			
Live	70.1%	77.0%	65.0%
Processed	29.3%	21.6%	35.0%
Prefer not to respond	0.6%	1.4%	0.0%
	All respondents	**Muslim respondents**	**Christian and other respondents**
Do you think Halal meat is safer than non-Halal meat?			
Yes	69.0%	91.9%	52.0%
No	16.7%	4.1%	26.0%
Prefer not to respond	14.4%	4.1%	22.0%
	All respondents	**Muslim respondents**	**Christian and other respondents**
Do you think Halal meat is of better quality than non-Halal meat?			
Yes	64.4%	85.1%	49.0%
No	21.3%	8.1%	31.0%
Prefer not to respond	14.4%	6.8%	20.0%
	All respondents	**Muslim respondents**	**Christian and other respondents**
Do you work for New Horizons?			
Yes	9.8%	6.8%	12.0%
No	85.1%	90.5%	81.0%
Prefer not to respond	5.2%	2.7%	7.0%

which likely increased its name recognition. Second, New Horizons had billboards across Nampula advertising its products (something which is rare in Northern Mozambique), which also may familiarize participants with its product. While name recognition may have driven the WTP, there was still the likely possibility of hypothetical bias where participants may be WTP a premium for New Horizons but not 20.7% if faced with an actual transaction. With all of that being said, this result was important because it suggested that even poor consumers, who oftentimes maximize caloric intake on a tight budget constraint, put value into branding.

The mean WTP premium for Halal (Table 2) was not significantly different from zero ($P > 0.10$), indicating that, on average, participants were not WTP a premium for a Halal-produced chicken. However, when looking at the interaction between Muslim and Halal (a subsample of only those who identified as being Muslim), there was a positive and significant ($P < 0.10$) coefficient on the marginal WTP. This result indicated that Muslim participants in the study were WTP 37.10 MZN more for poultry produced in a Halal manner over a non-Halal manner. This would represent a 19% premium for Halal poultry. Like with the branding coefficient, some caution needs to be used when interpreting this. There was likely more hypothetical bias in this estimate, given its association with "appropriate" religious behavior. Second, this survey was conducted during Ramadan, which likely influenced decision-making even more for Muslim participants.

These results would suggest two things. First, non-Muslims derive no utility from Halal-produced poultry in our study. One of the main hypotheses of this paper was to estimate if non-Muslims would be WTP for Halal as it could signal higher quality or safer food; this does not appear to be the case. Non-Muslims did associate Halal poultry with being safer (69%) and of better quality (64%), but they were not found to be WTP a premium for these attributes. Second, religious norms seemed to hold even in the face of poverty. It appeared that even in the poorest regions of one of the poorest countries of the world, Muslim consumers were WTP a premium to uphold their religious beliefs. These results are important as a large portion of Northern and coastal Mozambique is Muslim, and poultry production and consumption are growing nationwide. These results should not be used for exploitation (deriving the max WTP) but rather to show demand for a product.

Conclusions

Results from the small sample in this study indicated that even in low-income countries like Mozambique,

Table 2. Random parameter logit (RPL) model and respective marginal willing-to-pay (WTP) results.

Parameter	RPL	Marginal WTP
New Horizons Brand	0.506*** (0.109)[a]	40.51**
SD	0.759*** (0.166)	60.74**
Halal	-0.061 (0.143)	-4.86
SD	0.867*** (0.142)	69.37***
Halal x Muslim	0.464** (0.216)	37.10*
SD	0.055 (0.540)	4.40
ASC (No Buy)	-9.930*** (1.748)	-794.94***
SD	4.328*** (0.965)	346.45***
Price	-0.012*** (0.003)	-
SD	0.030*** (0.005)	-
Log L	-731.6	-
N[b]	1008	1008

[a] Standard errors, given in parentheses, are needed to calculate the marginal effects.
[b] N = 1008, given 312 respondents with responses to several information sets.
* Significant at the level $P < 0.1$.
** Significant at the level $P < 0.05$.
*** Significant at the level $P < 0.001$.
SD = standard deviation.

consumers are WTP a premium for branding. Specifically, Muslim consumers were WTP a premium for Halal-produced meat with branding. In communities like Nampula, branding could be a proxy for food safety concerns, given the lack of a food safety regulatory body. Companies could use Halal branding as a signal of safety and quality among meat products and could reach a market much larger than just Muslim consumers. This conclusion also proposes an ethical dilemma: whether companies should capitalize on the religious choices of consumers. Results indicate that producers could gain market share via labeling without necessarily having to raise the price of Halal poultry. Further, if there was a cost of production increase because of Halal production, this study provided empirical evidence of how much of that increased cost could be passed to consumers. Importantly, these results should not be used to exploit a religious belief but rather provide evidence that marketing towards a religious belief could increase market share.

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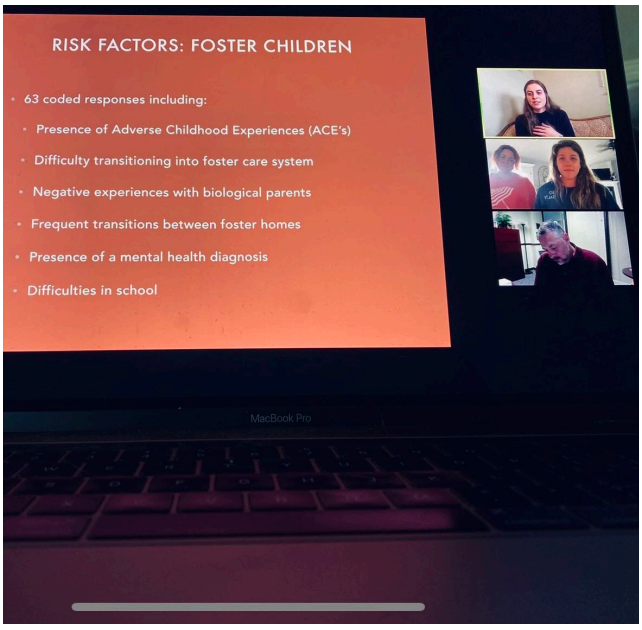
Needs of Foster Parents and Children

Meet the Student-Author

Emma Friemel

While working on my degree in Human Development and Family Science, I discovered my desire to work with underserved populations. I am interested in studying resiliency among foster parents and children, the effectiveness of rehabilitative services in the prison system, as well as resiliency and mental health of refugees resettling in the Northwest Arkansas area. Given these interests, I volunteered with 7Hills Homeless Shelter assisting homeless clients in obtaining food and services. Additionally, I volunteered with the Cooperative Emergency Outreach interviewing clients for financial assistance, gathering information on the current financial situation of clients, and determining the level of assistance. For my internship, I took a position at Canopy NWA, where I worked with refugees to aid them in gaining employment by advocating with local employers and employment specialists. I graduated from the University of Arkansas with a degree in Human Development and Family Science in 2020. I was on the Chancellor's and Dean's lists every semester from 2017 until I graduated. Following graduation, I am matriculating into the MSW program in the School of Social Work at the University of Arkansas. I would like to thank my mentor, Dr. Amanda Terrell, and my committee members Dr. Mike Merten and Dr. Jen Becnel.



Emma defending her thesis virtually like many students had to do this past year.

Research at a Glance

- The purpose of the research is to investigate the experiences, needs, and concerns of foster parents that promote foster child resiliency among families in Oklahoma.
- The Oklahoma State University Center for Family Resilience administered a survey to 316 prospective, current, and former foster parents regarding their experiences with the foster care system. The data was then analyzed using thematic analysis to determine themes based on Masten's resiliency theory.
- Findings suggest that children in foster care are likely to experience significantly more risk factors than protective factors, which is highly likely to influence their level of resilience. In addition to this, agency workers have a significant impact on the foster parent experience, which in turn affects the quality of care and resources that the foster child receives, affecting their likelihood to be resilient in future adverse situations.

Needs of Foster Parents and Children

Emma Friemel,[*] *Amanda Terrell,*[†] *Jennifer Becnel,*[§] **and** *Michael Merten*[‡]

Abstract

Children in foster care are likely to have experienced some form of adverse childhood experiences (ACEs). These ACEs can leave them vulnerable when faced with difficult future situations. There are several studies that examine the resiliency of children in foster care, but few examine foster children's resiliency from the perspective of the child's foster parents. The Oklahoma State University Center for Family Resilience administered a survey to 316 prospective, current, and former foster parents regarding their experiences with the foster care system. The data were analyzed using thematic analysis to determine themes based on Masten's resiliency theory. Themes were coded into protective and risk factors, experiences with agencies, and how the foster care system could be improved. The findings suggest that children in foster care are likely to experience more risk factors than protective factors, which is likely to influence their level of resilience. In addition, agency workers have a significant impact on the foster parent experience, which in turn affects the quality of care and resources that the foster child receives and affecting their likelihood to be resilient in the future.

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[‡] Michael Merten is the Newkirk Professor of Leadership in Child, Youth and Family Studies at the University of Nebraska-Lincoln.

Introduction

The foster system serves thousands of youths every year who would otherwise remain in an abusive or neglectful household. In 2017, over 440,000 children were in the foster care system in the United States (Children's Bureau, 2018a). In Oklahoma alone, there were over 10,000 children from 1 to 20 years of age in foster care in 2016 (The Annie E. Casey Foundation, 2018). Children may be placed in a foster home until their home is deemed safe enough for them to return. Both the foster child and foster parents must adapt their lives as they experience change and learn to become more resilient for future challenges. Foster care is a significant intervention that provides relief while the foster child's home situation is investigated. Many children are reunited with their primary caregivers after a length of time in foster care; however, many children may age out of the system, are adopted by their foster parents, or become emancipated (Oklahoma Department of Human Services, 2017). The average length of time for a child to remain in foster care in 2016 was 1–2 years (Children's Bureau, 2018b).

Foster youth likely accumulate several Adverse Childhood Experiences (ACEs), which can have lasting negative consequences (Harden, 2004). The ACEs are traumatic experiences that happen in childhood, such as physical/emotional/sexual abuse, neglect, or severe challenges in the household (Centers for Disease Control and Prevention, n.d.). The more ACEs a child experiences, the higher risk they are for having mental and physical health problems in later life. For example, individuals with 4 ACEs are 2 times more likely to develop cancer or heart disease. Those with 5 ACEs are 8 times more likely to become an alcoholic, and those with 6 or more ACEs have a life expectancy that is 20 years less than people with less than 6 ACEs (Felitti et al., 1998). All children in foster care automatically have at least one ACE due to the childhood maltreatment they experienced that placed them in the foster care system—many of these children will continue to accumulate multiple ACEs based on the severity of their situation and quality of foster placement (UNICEF, 2006; Vandervort et al., 2012). They are more likely to experience negative health effects, like obesity and heart disease, as well as performing worse academically and engaging in riskier behaviors (Centers for Disease Control and Prevention, 2018; Felitti et al., 1998; Stott, 2012). With the proper supports, the foster parent and child can develop a positive relationship with one another during their time together and avoid maladjustment (Simmel, 2007).

Based on Masten's resilience framework, resilience is the ability to "adapt successfully to disturbances that threaten the viability, the function, or the development of that system" (Masten, 2014). When an individual experiences adversity, it is important to examine the different factors that either hinder or promote the level of resiliency (Yates et al., 2015). Risk factors include anything that contributes negatively to an individual's outcome, such as low income or a history of trauma (Masten, 2011). On the other hand, promotive factors, or assets, are resources that typically help and assist any individual's outcome at every level of risk (Masten, 2018). Protective factors are like promotive factors but are more focused on mitigating the potential for negative outcomes. (Masten, 2018). Thus, the purpose of the current study is to identify features and experiences within the foster care system that would contribute to or hinder resiliency among children and their foster families from the perspective of foster parents. These features and experiences will be identified based on key concepts from Masten's resiliency framework (i.e., identification of assets, risks, promotive factors, and protective factors; Masten, 2018, 2011, 2001).

Materials and Methods

Data for this study come from the 2017 Oklahoma State University Center for Family Resilience Foster Parent Survey. A total of 316 foster parents were administered an online survey via Qualtrics, asking them questions about their various experiences parenting foster children, child needs, and interactions with foster care system staff and administrators. The survey includes basic questions about demographics, employment, age, etc., as well as questions about their involvement with their foster children and the system, resources they may have had, different forms of education they've received about foster care, etc. The current study specifically focuses on parents' written responses to the following open-ended items:

- What experiences and/or situations prevent you from considering fostering?
- Please list your reasons for considering quitting and/or quitting the foster system.
- What is the most important thing a foster child needs?
- What challenges do/did/will you face as a foster parent?
- What challenges do foster children face?
- To feel more supported/respected as a foster parent, the following can be done.

A qualitative approach was used to look for common experiences, concerns, and needs reported by foster parents that would theoretically contribute to or hinder resiliency processes. Based on Braun and Clarke's (2006) thematic process for analyzing qualitative data, the survey data were examined for reoccurring themes among the foster parents' responses. Initial data analysis involved pulling relevant quotes from parents' survey responses and assigning

them a code—either based on Masten's resilience theory or in vivo—along with a definition for the code. After coding the responses, reoccurring themes from the codes were determined and then refined. For each theme, an analysis was conducted to ensure there was no overlap between themes. To ensure the reliability of the codes, another individual coded 10% to 15% of the survey responses. Finally, a report of the final themes from the foster parent surveys was written in order to relate the research back to the research question (Braun and Clarke, 2006).

Results and Discussion

This study sought to bring awareness to the various factors that can either hinder or promote resilience among children in foster care. The survey responses included discussion involving risk factors (170), protective factors (84), experiences with agencies (75), and ways to improve the foster care system (46) (Fig. 1). A breakdown of the total number of comments made about each theme is included in Table 1, and illustrative quotes are in Table 2. Consistent throughout the responses was the difficulty and frustration of being a foster parent because of the plethora of risk factors associated with the foster child and foster parent experience. Based on many of the survey responses, there were several common themes that including protective factors, risk factors, agency worker experiences, and suggestions to improve the foster care system as a whole.

Protective factors are crucial in promoting resilience among foster children and to mitigate the effects of risk factors faced by foster parents and children. Compared to the number of responses given regarding risk factors, responses including protective factors were mentioned less than half the time. There was significant discussion about the importance of foster children being in an environment of love, stability, structure, consistency, understanding, acceptance, safety, security, and support—most of which are provided by foster parents in the home to promote resiliency.

The foster parents in the survey noted numerous risk factors that their children have experienced that have contributed negatively to their possibility of resilience. The responses included discussion involving ACEs, the difficulty of transitioning into the foster care system, negative experiences with the child's biological parents (adverse childhood experiences), frequent transitions between several foster homes, the presence of mental health diagnoses, and the struggles these children face in school.

Over half of the survey responses included experiences and concerns for both foster parents and foster children that could contribute negatively to the foster child's outcome. Foster parents had risk factors specifically associated with their own experiences, including a feeling of being burned out, the demands of being a foster parent, feeling a lack of support from agency workers, receiving poor treatment from agency workers, and feeling like they did not receive enough information regarding their foster child placement. One parent echoed several of these frustrations in their survey responses.

In addition to the components of Masten's resilience theory, two other themes emerged from the data. Many

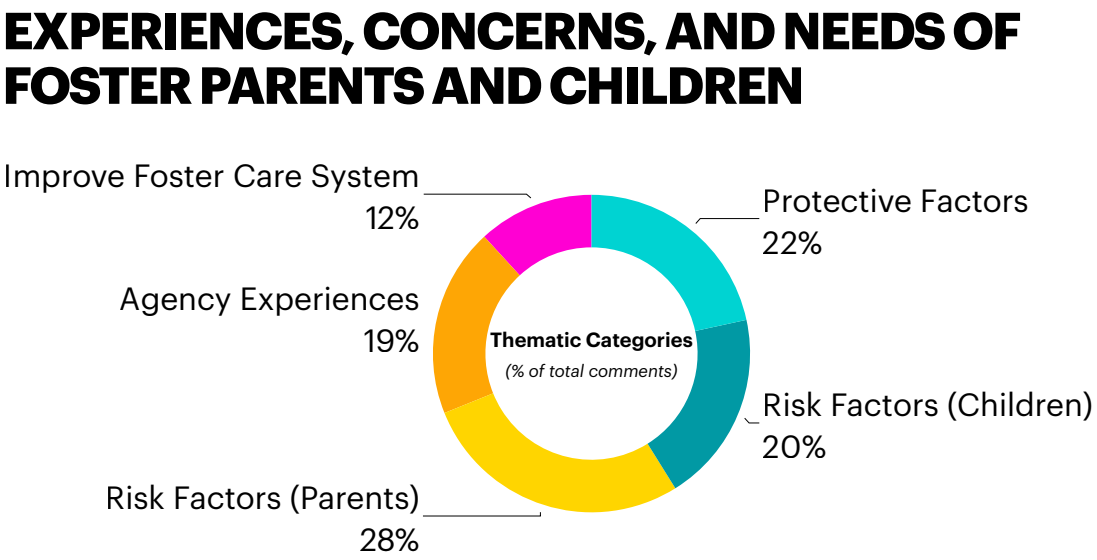

Fig. 1. Experiences, concerns, and needs of foster parents and children.

Table 1. Thematic categories and number of comments in the qualitative coding.

Thematic Categories	Theme	Number of Comments
Protective Factors (Total)		**84**
	Love	32
	Stability/Structure	17
	Consistency	13
	Support/Understanding/Acceptance	12
	Safety/Security	10
Risk Factors (Foster Children) (Total)		**63**
	Difficult Transitions	24
	Adverse Childhood Experiences	14
	Presence of Mental Health Diagnosis	10
	Difficulties in School	9
	Frequent Transitions in Foster Care	6
Risk Factors (Foster Parents) (Total)		**108**
	Negative Experiences with Support Agencies	29
	Demandingness of Being a Foster Parent	24
	Poor Treatment of Foster Parents	20
	Lack of Support	19
	Lack of Information	9
	Burnout	7
Experiences with Agencies (Total)		**75**
	Negative Experiences	29
	Lack of Communication	*20*
	Foster Parent not Feeling Heard/Valued	*12*
	Preference given to Biological Parents	*8*
	Positive Experiences	6
Ways to Improve Foster Care System (Total)		**46**
	More Information	15
	Expand Foster Parent and Child Rights	11
	Taking Foster Parents' Concerns and Thoughts More Seriously	9
	Better Communication	5
	Following Through with Needs of Foster Parents and Children	3
	Expand Mental Health Resources	3

Table 2. Illustrative quotes from the 2017 Oklahoma State University Center for Family Resilience Foster Parent Survey.

Theme	Quotes
Protective Factors	*"To feel safe, then to feel loved. This is often achieved through structure and consistency."* *"Knowing their self-worth and creating meaningful bonds with caregivers and/or parents. Self-Control. Sense of belonging. Knowing unconditional love."*
Risk Factors	*"Each child is unique and their challenges are unique to them. But they face the worry of will they want me? New bed, new school, new faces, new everything. They have been through their own trauma, their own hell, and as such we need to help them heal. It's not as easy as a band aid fix. Their wounds are much more serious and need time to heal. They need love to heal but it won't happen overnight."* *"There is no support for foster parents. We are ostracized if we ask for help, we are regarded as uncaring if we have to put our own family's needs first. We spend countless hours and money attending trainings on how to manage the behaviors of the children in our home but when a problem arises, we have no say in the care the children receive."*
Experiences with Agencies	*"I had one caseworker who was INCREDIBLE."* *"The other children's worker was awful- terrible about responding to emails/texts/calls, dismissive of concerns, treated us poorly/suspiciously. If this worker had been our first worker, we would have immediately closed our home."*
Improving the Foster Care System from Foster Parents Perspective	*"Clear communication with respect from DHS, an understanding and paradigm within DHS that the foster families are allies. No retaliation when foster parent disagrees with DHS."* *"Listen to concerns, be included as part of the "team", be involved in the child's case, be informed of the case details."*

of the foster parents expressed frustrations and negative experiences with agencies like DHS, whose purpose is to better the life of the foster child and provide proper supports to all parties involved with the foster care system. Most of the responses involving these agencies were incredibly undesirable and involved some sort of discussion that left the foster parents feeling unheard or unvalued, that there was a clear preference given to the child's biological parents, and that there was an immense lack of communication given to the foster parent regarding their foster child.

Among the responses given in the survey, a plethora of answers included some sort of experience with an agency worker assigned to the individual's foster child and foster home. The responses were analyzed to determine the overall attitude of the foster parent towards the agency worker and if their experiences were more geared towards being a risk factor or a protective factor. The experiences were classified as positive if the response included some form of praise towards an agency worker in the past. On the other hand, negative agency worker experiences were classified based on if the response included some form of criticism or frustration towards the agency worker.

The results showed that there were almost five times more negative experiences with agency workers than positive experiences. Often, foster parents expressed that their caseworkers or other agency workers communicated poorly, left the foster parent feeling unvalued or unheard, or the foster parent felt that there was a preference towards the foster child's biological parent(s). There was very little discussion about the characteristics that made certain agency worker experiences positive.

A surprising number of responses given from the survey were geared towards ways that foster parents wished the foster care system was improved to better their overall experience as foster parents. This data was not originally intended to be analyzed; however, almost 50 responses included some form of suggestion by the foster parent to improve their experience for future foster child placements. Almost all of these responses included ways that agency workers could improve their interactions with foster parents, such as providing more information regarding the foster child placement, giving the foster parent greater rights regarding their foster child, taking the concerns and thoughts of foster parents more seriously, increasing the accessibility of resources regarding mental health services for the foster child, and following through with the promises made to foster parents and their foster children.

A significant strength of this study is the number of foster parent participants who chose to take part in the survey. The survey included responses from 316 individuals who have been foster parents or are considering becoming foster parents for the foster care system in Oklahoma, and from the data, over 375 items were coded for this research, with certain items being cross-coded. The open-ended items allowed for parents to share their experiences regarding their foster child and the system thoroughly and in-depth regarding risk factors, protective factors, interactions with agency workers, and suggestions to improve the system. A limitation of the study is the lack of participant responses regarding promotive factors. This could be attributed to the inclination for evaluation comments to skew negative (Ito et al., 1998). It is important to take into consideration the promotive factors that the foster parent and foster child have experienced in order to have the best overall picture of the likelihood of resilience in future adverse situations. It is an essential element of Masten's Resilience Theory, and unfortunately, is lacking in this research (Masten, 2011).

Conclusions

The results of this study show that children and parents involved in the foster care system experience a variety of risk and protective factors that either promote or hinder resiliency among foster children. Firstly, the most significant risk factors that were mentioned were categorized into either risk associated with the foster parents or risks associated with the foster children. Risks associated with foster children mentioned in the survey responses included adverse childhood experiences (ACEs), difficult transitions once entering foster care, the presence of mental health disorders, the number of transitions between foster homes, difficulties in school, and connections with the child's biological parents. Risks associated with foster parents mentioned in the survey responses included risk factors from the parents' life outside of foster care, lack of support for parents, negative experiences with support agencies, poor treatment of foster parents, the demands of being a foster parent, and a lack of information given to foster parents. Other findings in the study included positive and negative experiences with agencies meant to support foster children, as well as ways that the foster system could be improved from the perspective of a foster parent. All of these components lead to the overall level of resiliency in the foster child when faced with future adverse situations.

Acknowledgments

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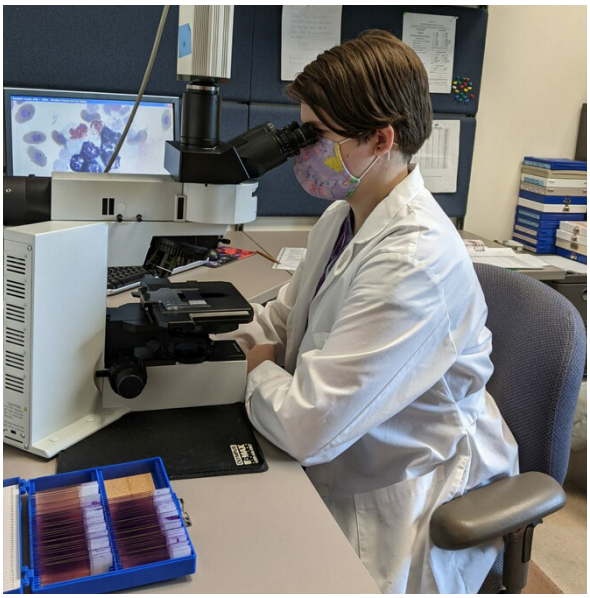
Effects of a Low Crude Protein Diet With and Without *Spirulina platensis* Inclusion on White Blood Cell Profiles in Broilers

Meet the Student-Author

Heather Glenn



Heather is identifying white blood cells on a Wright-stained blood smear to determine the proportions among different white blood cells. An image of white blood cells she viewed under the microscope is displayed on the image analysis computer screen.

I am a Spring 2021 Magna Cum Laude graduate of the Dale Bumpers College of Agricultural, Food, and Life Sciences with a degree in Poultry Science. Before attending the University of Arkansas, I was an active Future Farmers of America (FFA) member at Fayetteville High School. I participated in the FFA Veterinary Science contest, where my team and I went to the state competition. At the University of Arkansas, I was awarded the Honor's Fellowship, which is an exclusive scholarship awarded over four years to the top incoming freshmen. I also received the Arkansas Distinguished Governor's Scholarship for the four years of my studies. Poultry Science allowed me to explore my different interests and provided numerous opportunities for me as a student and as a graduate. The Poultry Science Department gave me the opportunity to learn and practice different lab techniques through their Honors Current Approaches in Agricultural Laboratory Research class. I also had the chance to raise chickens from hatch through the Poultry Productions class. The Poultry Science Department gave me so many wonderful experiences, including this research project. I'd like to thank my research mentor, Dr. Gisela F. Erf, for all her help and guidance with the project, and my research committee members, Dr. Samuel J. Rochell and Dr. Sara K. Orlowski. I'd also like to thank my lab mates Chrysta Beck, Jossie Santamaria, and Dr. Marites Sales for their help with blood smear preparation and flow cytometry analyses.

Research at a Glance

- *Spirulina* is investigated as an environmentally friendly source of protein for inclusion in low protein broiler diets formulated to sustain growth performance and health.
- *Spirulina* inclusion in a low protein diet had no effect on white blood cell profiles and prevented increased levels of inflammatory cells observed with the low protein diet.
- This study also contributed comprehensive white blood cell population data for modern commercial broilers.

Effects of a Low Crude Protein Diet With and Without *Spirulina platensis* Inclusion on White Blood Cell Profiles in Broilers

***Heather Glenn,*[*] *Garrett J. Mullenix,*[†] *and Gisela F. Erf*[§]

Abstract

Spirulina microalgae is an alternative protein source under consideration for feed formulation in commercial broiler production. The purpose of this study was to determine the effects of a low crude protein (LCP) diet and a LCP diet formulated with 100 g/kg *Spirulina* (LCP-SP) on blood cell measurements in broilers. One-day-old Ross 708 male broilers were assigned to three dietary treatments: a standard crude protein (SCP), the LCP, or the LCP-SP diet, with five pens/treatment. When the chickens were 37-days old, blood samples were obtained from 2 birds/pen. Each blood sample was used to determine 1) the concentrations of white blood cells (WBC), thrombocytes, red blood cells (RBC), hemoglobin, and hematocrit by automated hematology; 2) the proportions among WBC populations by microscopic evaluation of >300 WBC on Wright-stained blood smears; and 3) the proportions among lymphocyte-subsets by immunofluorescent staining and flow-cytometric cell population analysis. Except for monocytes, none of the blood cell measurements were affected ($P > 0.05$) by diet. The LCP diet resulted in increased ($P \leq 0.05$) monocyte concentration and proportion compared to the SCP diet, indicating heightened inflammatory activity with lower dietary protein content. The LCP-SP diet reversed the effect of the LCP diet, resulting in monocyte concentrations and proportions not different ($P > 0.05$) from those of the SCP diet. The ability of *Spirulina* microalgae to maintain normal WBC profiles in broilers fed the LCP diet is a promising sign for its use as a proteinaceous feed component without compromising the health of the bird.

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[†] Garrett J. Mullenix is a Ph.D. graduate student in Poultry Science.
[§] Gisela F. Erf, the faculty mentor, is an Immunologist and a Tyson Endowed Professor in Avian Immunology.

Introduction

Protein is one of the more expensive feed components in commercial broiler production. One risk of cutting down protein content in feed is that it may have damaging effects on the chicken's immune system and natural defenses. Broilers fed diets deficient in amino acids had reduced primary antibody responses compared to broilers fed a typical diet (Kidd, 2004). Protein deficiency also decreased lymphocyte numbers and overall white blood cell numbers (Kidd, 2004). Similarly, altered innate immune system activities were observed with low crude protein diets, even when the reduced crude protein diets were formulated to maintain a normal digestible amino acid content (Mullenix et al., 2021). Specifically, compared to broilers fed a standard protein diet, broilers fed a low crude protein diet had increased bacterial translocation across the gut mucosal epithelium and exhibited systemic inflammation as indicated by upregulated mRNA expression of circulating pro-inflammatory cytokines, chemokines, and the NLRP3 inflammasome. Hence, research is underway to identify alternative nutrient sources for the formulation of low protein diets that sustain growth performance and health of broilers.

One feed additive that poultry researchers are examining is *Spirulina (Arthrospira) platensis*. *Spirulina* is a blue-green cyanobacterium microalga that can be consumed by humans and animals. It not only is a rich source of high-quality protein but also has antioxidant, immunomodulatory, anti-inflammatory, antiviral, and antimicrobial properties (Park et al., 2018; Mullenix et al., 2021). At up to 5% consumption, *Spirulina* had no long-term toxic side effects (Yang et al., 2011). When administered for the first 21 days of a broiler's life, dietary *Spirulina* supplementation resulted in similar immune system changes to in-feed antibiotics, with a lower number of leukocytes, lymphocytes, and eosinophils (Sugiharto et al., 2018). Moreover, as reported by Mullenix and colleagues, formulation of *Spirulina* into a low protein diet reduced the systemic inflammation and bacterial translocation observed with the low crude protein diet, supporting the use of *Spirulina* as an alternative protein source in poultry diets (Mullenix et al., 2021).

Analysis of blood cell populations provides important insight into immune system development and function (Erf et al., 1996; Wang et al., 2003). The purpose of this study was to examine white blood cell profiles in broilers fed a low crude protein (CP) diet with and without *Spirulina* inclusion. Specifically, blood measurements conducted included determination of concentrations and proportions of various white blood cell (WBC) populations (i.e., lymphocytes, heterophils, monocytes, basophils, and eosinophils) and lymphocyte subsets (i.e., B cells, T helper cells, cytotoxic T cells, and T-cell receptor defined sub-populations). It was hypothesized that the inclusion of *Spirulina* in the low protein diet would return potential alterations in WBC profiles to levels comparable to those in broilers fed the standard diet.

Materials and Methods

The live performance phase of this experiment was described by Mullenix et al. (2021). Briefly, a total of 180 one-day-old male Ross 708 broiler chicks were allotted randomly to one of 15 floor-pens (5 pens/diet; 12 birds/pen) on wood shavings litter. The temperature gradually decreased from 32 °C on the day of placement to 20 °C by day 27. Birds received 23 h of light until day 10, at which time the light duration was decreased to 18 h for the remainder of the trial. Birds were given *ad libitum* access to feed and water throughout the trial. A standard corn-soybean meal basal diet (3250 kcal/kg, 21% CP) was fed to all birds until day 14, at which point experimental diets were introduced until 37 days of age. The experimental diets included an industry standard level protein (~20% CP) corn/soybean meal control (SCP) diet, reduced (~17% CP) corn/soybean meal diet (LCP), and LCP diet where *Spirulina* was formulated into the diet at 100 g/kg (LCP-SP). All experimental diets were isocaloric and met all essential amino acid needs set forth by the primary breeder. Both low crude protein diets were formulated to be isonitrogenous (Mullenix et al., 2021). The animal study was reviewed and approved by the University of Arkansas Animal Care and Use Committee (protocol # 21002)

On day 37, 3-mL heparinized blood samples, collected from birds selected randomly (10 birds/treatment; 2 birds per pen; $n = 5$), were provided by Mullenix et al. (2021). A portion (1 mL) of each blood sample was used to determine the concentrations of WBC, thrombocytes, red blood cells (RBC), hemoglobin, and hematocrit using an automated hematology analyzer (Cell-Dyn; Abbot Diagnostics, Abbott Park, Illinois) calibrated for chicken blood (French et al., 2020). The remaining blood was used to prepare blood smears and mononuclear cell suspensions.

Blood smears were prepared on glass slides, stained with Wright stain (Lucas and Jamroz, 1961), and examined at 1000×-magnification with oil immersion using a bright field microscope (Olympus BX50, Meyer Instruments, Houston, Texas). At least 300 Wright-stained WBC in the monolayer of blood were evaluated across the slide and the number of observed lymphocytes, heterophils, monocytes, eosinophils, and basophils were recorded (Wang et al., 2003). The percentage of each cell type (% WBC) was calculated by dividing the number

of a cell-type by the total number of WBC evaluated and multiplying by 100. The concentration of each of the WBC populations was calculated using the proportion of each cell type and the total WBC concentration determined by automated hematology. The heterophil/lymphocyte ratio was calculated by dividing the heterophil concentration by the lymphocyte concentration.

Peripheral blood mononuclear cells (PBMC), consisting of lymphocytes, monocytes, and thrombocytes, were isolated from 1 mL of each blood sample by density gradient separation over Ficoll 1.077. For this, 1 mL of blood was mixed with 1 mL of room temperature Dulbecco's phosphate-buffered saline (PBS; Sigma, Chemical Company, Saint Louis, Missouri). The diluted blood samples were then carefully layered on top of 2 mL of Ficoll (Sigma). The Ficoll-blood mixture was centrifuged at room temperature at 400 × *g* for 30 min. After centrifugation, the layer of PBMC at the Ficoll-plasma interphase was collected, mixed with 3 mL of cold PBS, and the cells were washed by centrifugation at 4 °C for 8 minutes at 250 × *g*. After centrifugation, the supernatant fluid was discarded, the cell pellet resuspended in 3 mL of cold PBS, and the cell suspension washed again as before. The final cell pellet was resuspended in 1 mL of cold PBS+ (PBS containing 1% bovine serum albumin and 0.1% sodium azide) staining buffer, and the cell suspensions were left on ice until use.

A direct, one- or two-color staining procedure was followed to identify various lymphocyte subsets in the PBMC suspensions (French et al., 2020). For each broiler, PBMC were incubated with fluorescently labeled mouse monoclonal antibodies (mAb) specific for chicken lymphocyte populations and thrombocytes. Four combinations of mouse-anti-chicken (mac-) mAb were used to identify 1) CD4+ T helper cells [CD4-FITC; mac-CD4 mAb conjugated to fluorescein isothiocyanate (FITC)] and CD8+ cytotoxic T cells [CD8-PE, mac-CD8α mAb conjugated to phycoerythrin (PE)], 2) B cells [Bu-1-PE] and T cells [CD3-SPRD, spectral red fluorochrome (SPRD) conjugated mac-CD3 mAb], 3) T cells with αβ T cell receptors [αβ1- & αβ2-TCR-FITC] and T cells with γδ TCR [γδTCR-PE], and 4) thrombocytes [CD41/61-FITC]. All lymphocyte-specific mAb were purchased from Southern Biotech, Birmingham, Alabama. The chicken thrombocyte-specific mAb was purchased from BioRad Life Science, Hercules, California. All mAb used were IgG1 and were prepared at 1:100 dilution in PBS+.

For each PBMC sample, the cells (50 µL) and reagents (50 µL) were added to 4 wells of 96-well round-bottom plates and incubated at 4 °C for 30 min. After the incubation, cells were washed twice in PBS+ by centrifugation of plates at 4 °C for 4 min at 250 × *g*. After the final wash, the pellet was resuspended in 200 µL PBS+ for flow cytometric analysis.

Staining controls included: an isotype control to examine the non-specific binding of antibodies and determine the cut-off between negative and positive fluorescence, and single-stained cells to adjust fluorescence compensation. For controls, a pooled sample of PBMC was used and incubated with a cocktail of mIgG1 isotype control antibodies (no specificity for chicken molecules) labeled with FITC, PE, or SPRD, or, for the single staining controls, with leukocyte-specific mAb CD45-FITC, or CD45-PE, or CD45-SPRD.

For flow cytometric analysis, each sample was mixed well, transferred into a 1.5-ml microcentrifuge tube, and placed on the sample port of a BD C6 Accuri flow cytometer (Becton Dickinson, San Jose, California) for the acquisition of the percentage of each cell type based on light scatter characteristics (FSC-size, SSC-granularity) and FL-1 (FITC fluorescence), FL-2 (PE-fluorescence), and FL-3 (SPRD fluorescence). The data were analyzed using FlowJo software v. 1.05. A region was drawn around the small PBMC population containing lymphocytes and thrombocytes and the percentage of each cell type (B cells and CD4+, CD8+, αβ and γδ TCR+ T cells, thrombocytes, and lymphocytes) determined based on their fluorescent staining. For each sample, the proportion of the various lymphocyte subsets were then expressed as a percentage of lymphocytes by calculation (i.e., dividing the proportion of each lymphocyte population by the proportion of total lymphocytes in the small PBMC population and multiplying by 100). The total T cell population was calculated by adding the proportions of αβ- and γδ-TCR+ T cells. The T/B cell ratio was calculated by dividing the T cell population by the B cell population estimates for each sample. Similarly, the CD4+/CD8+ T cell ratio was calculated by dividing the CD4+ T cell population by the CD8+ T cell estimates for each sample. The concentrations of each lymphocyte population were calculated by multiplying the percentage of each lymphocyte subpopulation by the total blood lymphocyte concentration determined by Cell-Dyn as described above and dividing by 100.

All cell population data were analyzed for the effect of diet by one-way analysis of variance using SigmaPlot (Systat Software, Inc, San Jose, California). Differences were considered significant at $P \leq 0.05$. If there was a significant diet difference, means were compared using a Student's *t*-test and a Welch's *t*-test. Differences were considered significant at $P \leq 0.05$.

Results and Discussion

The immune system of chickens, like that in mammals, consists of innate and adaptive immunity. Innate immunity includes physical and chemical barriers that prevent

entry of a pathogen, as well as soluble and cellular components working to eliminate or contain the pathogens that infected an individual (Abbas et al., 2018). Cells of innate immunity include phagocytes like heterophils (the avian counterpart to neutrophils) and monocytes/macrophages, as well as granulocytes like eosinophils that fight larger parasites, and basophils that release pro-inflammatory factors. If innate immunity cannot eliminate the pathogen, the more specific adaptive immunity will be called into action. Lymphocytes, specifically B- and T-cells, are the cells of adaptive immunity, with B cells being responsible for antibody production and T cells for cell-mediated immunity. There are several subsets of T cells, such as the CD4+ T helper cells that are critical in the activation of adaptive immunity, CD8+ cytotoxic T cells that eliminate infected host cells, and T cell populations defined by the type of T cell receptor they have to bind antigen (i.e., T cells with αβ TCR that are restricted to recognizing antigen-peptides displayed on MHC-molecules of an antigen-presenting cell, and γδ T cells that do not need antigen presentation and are able to readily respond to frequently encountered microbes) (Abbas et al., 2018). All these WBC circulate in the blood, ready to be called to the tissues to fight infections. Considering the different functions of various WBC in innate and adaptive immunity, analysis of the concentrations and proportions of WBC populations is an important diagnostic tool to determine the health and disease of an individual (Abbas et al., 2018; French et al., 2020). This same approach also provides important insight into the influence of nutrition on immune system development and function (Klasing, 2007; Chandra et al., 2015; French et al., 2020).

The purpose of this study was to examine white blood cell profiles in broilers fed a low crude protein diet with and without *Spirulina* inclusion compared to a standard crude protein diet. The analyses conducted revealed no effect of the three diets on the concentrations of WBC, thrombocytes, RBC, hemoglobin, and hematocrit (Table 1) and on the concentrations and proportions of heterophils, lymphocytes, basophils, eosinophils, and the various lymphocyte populations examined (Tables 2 and 3). Additionally, the ratios between heterophils and lymphocytes (Table 2), as well as the T cell to B cell and the CD4+ T cell to CD8+ T cells ratios (Table 3), were not affected ($P < 0.05$) by dietary treatment. However, the concentration and the proportions of monocytes were greater ($P < 0.05$) in broilers fed the LCP diet. The inclusion of *Spirulina* in the LCP diet returned monocyte levels to those observed with the SCP control diet (Table 2). Hence it appears that low crude protein content in the broiler diet stimulates inflammatory activity in healthy, fast-growing broilers that can be observed in the peripheral blood circulation. The addition of 10% *Spirulina* in the LCP diet did not alter the normal blood cell profiles in broilers and prevented the increase in monocytes observed with the LCP diet.

Similar observations were reported by Mullenix et al. (2021) for broilers from the same experiment as the current study. They reported increased ($P < 0.05$) expression levels of pro-inflammatory cytokines, chemokines, and the NLRP3 inflammasome in blood from broilers fed the LCP diet. The increased inflammatory activity was also not observed when *Spirulina* was included in the LCP diet. These findings are in line with our observation of increased proportions and concentrations of monocytes, especially since monocytes are the most likely source of the reported inflammatory activity observed in broilers fed the LCP diet (Abbas et al., 2018).

Conclusions

Analysis of blood cell profiles revealed increased inflammatory activity, i.e., elevated proportions and con-

Table 1. Concentrations of blood cells, hemoglobin, and hematocrit in of 37-day old male Ross 708 broilers reared on either a standard corn/soy (SCP) diet, a low crude protein (LCP) diet, or the LCP diet formulated with 100 g/kg *Spirulina* (LCP-SP).

Blood measurement	SCP	LCP	LCP-SP	*P*-value
WBC ($10^3/\mu L$)†	11.8 ± 1.84‡	13.9 ± 1.41	13.8 ± 1.16	0.561
Thrombocytes ($10^3/\mu L$)†	2.07 ± 0.13	1.98 ± 0.22	1.78 ± 0.14	0.467
RBC ($10^6/\mu L$)†	2.63 ± 0.04	2.70 ± 0.06	2.70 ± 0.04	0.517
Hemoglobin (g/dL)†	7.71 ± 0.35	7.79 ± 0.10	7.88 ± 0.14	0.658
Hematocrit (g/dL)†	61.1 ± 1.91	62.5 ± 1.05	63.2 ± 1.17	0.444

† Concentrations measured using an automated hematology analyzer.

‡ Data are mean ± SEM; n = 5; blood from 2 broilers processed per replicate.

Table 2. White blood cell (WBC) concentrations and proportions of 37-day old male Ross 708 broilers reared on either a standard corn/soy (SCP) diet, a low crude protein (LCP) diet, or the LCP diet formulated with 100 g/kg *Spirulina* (LCP-SP).

WBC Measurements	SCP	LCP	LCP-SP	*P*-value
Heterophils (10^3/µL)†	1.39 ± 0.30¶	1.84 ± 0.34	1.60 ± 0.19	0.548
Heterophils (% WBC)‡	11.5 ± 1.33	12.9 ± 1.22	11.60 ± 0.85	0.637
Lymphocytes (10^3/µL)†	9.58 ± 1.44	8.70 ± 1.01	11.23 ± 1.03	0.592
Lymphocytes (% WBC)‡	81.4 ± 1.97	78.8 ± 1.84	81.29 ± 1.00	0.478
Monocytes (10^3/µL)†	0.236 ± 0.027 b	0.503 ± 0.082 a	0.370 ± 0.076 ab	0.046
Monocytes (% WBC)‡	2.17 ± 0.35 b	3.64 ± 0.50 a	2.84 ± 0.77 ab	0.079
Basophils (10^3/µL)†	0.32 ± 0.074	0.31 ± 0.088	0.26 ± 0.020	0.970
Basophils (% WBC)‡	2.60 ± 0.21	2.16 ± 0.43	1.88 ± 0.14	0.185
Eosinophils (10^3/µL)†	0.285 ± 0.075	0.311 ± 0.058	0.290 ± 0.045	0.949
Eosinophils (% WBC)‡	2.31 ± 0.40	2.33 ± 0.44	2.18 ± 0.45	0.965
Heterophil/Lymphocyte Ratio§	0.143 ± 0.019	0.165 ± 0.043	0.143 ± 0.012	0.573

† The concentration of individual leukocyte populations was calculated using the WBC concentration (Table 1) multiplied by the proportion of each leukocyte population (% WBC) divided by 100.

‡ Manual differential leukocyte count to determine proportions (% WBC) of individual leukocytes populations based on evaluation of ≥ 300 WBC.

§ Heterophil/Lymphocyte ratio was calculated by dividing the heterophil concentration by the lymphocyte concentration.

¶ Data are mean ± SEM; n = 5; blood from 2 broilers processed per replicate, a, b**:** means within a row without a common letter are different $P \leq 0.05$ based on multiple means comparisons.

Table 3. Concentrations and proportions of various lymphocyte populations in blood from 37- day old male Ross 708 broilers reared on either a standard corn/soy (SCP) diet, a low crude protein (LCP) diet, or the LCP diet formulated with 100 g/kg *Spirulina* (LCP-SP).

Lymphocyte population	SCP	LCP	LCP-SP	*P*-value
B cells (10^3/µL)†	1.63 ± 0.30#	2.00 ± 0.40	1.76 ± 0.22	0.713
B cells (%)‡	16.8 ± 1.81	17.8 ± 1.99	15.5 ± 1.04	0.646
T cells (10^3/µL)†	7.95 ± 1.20	8.88 ± 0.66	9.47 ± 0.85	0.523
T cells (%)‡	83.2 ± 1.81	82.2 ± 1.99	84.5 ± 1.04	0.646
CD4+ T cells (10^3/µL)†	3.66 ± 0.51	4.12 ± 0.35	4.18 ± 0.22	0.585
CD4 + T cells (%)‡	39.0 ± 2.65	38.2 ± 1.73	38.1 ± 2.80	0.756
CD8+ T cells (10^3/µL)†	1.82 ± 0.19	2.17 ± 0.23	2.40 ± 0.19	0.166
CD8+ T cells (%)‡	19.7 ± 1.65	20.1 ± 1.58	21.5 ± 0.58	0.340
αβTCR+ T cells (10^3/µL)†	5.86 ± 0.95	6.73 ± 0.57	6.79 ± 0.69	0.627
αβTCR+ T cells (%)‡	60.9 ± 1.46	62.3 ± 2.61	60.5 ± 2.08	0.814
γδTCR+ T cells 10^3/µL)†	2.47 ± 0.44	2.46 ± 0.19	2.98 ± 0.34	0.491
γδTCR+ T cells (%)‡	25.4 ± 1.66	22.9 ± 1.05	26.4 ± 1.38	0.224
T cell/B cell Ratio§	5.58 ± 0.68	5.02 ± 0.63	5.72 ± 0.40	0.679
CD4+/CD8+ T cell Ratio¶	0.143 ± 0.019	0.165 ± 0.043	0.143 ± 0.012	0.548

† The concentration of individual lymphocyte populations was calculated by multiplying the lymphocyte concentration (Table 2) by the proportion (%) of each lymphocyte population and dividing by 100.

‡ The % of various lymphocyte populations is based on immunofluorescent staining of peripheral blood mononuclear cells and cell population analysis by flow cytometry.

§ The T cell/B cell ratio was calculated for each sample using the T cell concentration and the B cell concentration.

¶ The CD4+/CD8+ cell ratio was calculated for each sample using the CD4+ concentration and the CD8+ concentration.

Data are mean ± SEM; n = 5; blood from 2 broilers processed per replicate.

centrations of monocytes, with the LCP diet that agreed with more complex measurements made by others. This underlines the usefulness of blood cell profile analyses as a window into normal immune system development and function in broilers. Formulation of *Spirulina* into the LCP diet did not alter blood cell profiles compared to the SCP diet and maintained normal monocyte levels. Taken together, these observations support further investigation of *Spirulina* microalgae as a proteinaceous feed component that does not compromise the health of broilers. Lastly, using automated hematology, manual differential WBC counting, and immunofluorescent staining to identify various lymphocytes subsets, this study contributed comprehensive WBC data for modern commercial broilers.

Acknowledgments

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The Role of Peer Irrigators on the Choice and Intensity of Use of Irrigation Techniques

Meet the Student-Author

Noah Hayward

Noah at his May 2021 graduation ceremony, where he received Magna Cum Laude High Honors.

At a young age, I knew I always wanted to be a Razorback, and in 2017 I made this dream come true by continuing my education at the University of Arkansas. Prior to this, I grew up in Springdale, Arkansas, where I attended Har-Ber High school from 2015 to 2017. After high school graduation, I began to think about what I wanted to do in life and what kind of career path I wanted to pursue. After careful consideration, I decided to pursue an agricultural business degree to take advantage of the great business opportunities around us. It was truly the best decision I ever made. Looking back now, I see the wonderful and open community this represents. I was more than just another student or number but a voice to be heard with endless educational potential. As a freshman, I decided to take my academics to a higher level by joining the Dale Bumpers Honors College. My mentor Dr. Kent Kovacs helped me to achieve higher levels of success by guiding me through the process. I also thank Dr. Lanier Nalley for keeping me on the right track and leading me through my academic success. Lastly, I want to give great thanks to my committee, Dr. Michael Popp and Dr. Qiuqiong Huang, for helping improve my study. After graduation, I will work as a production supervisor for Simmons Foods, a top 20 poultry company in the United States.

Research at a Glance

- Evaluated the relationship between the irrigation practices in use by farmers' peers and the use and intensity of five common irrigation practices.
- Peer irrigation practice variables interact with the location and farm practices of the agricultural operation to examine heterogeneity in the peer relationship.
- A peer's use of a particular practice has a significant impact on the farmer's use of that same practice, but the impact can differ substantially by location within Arkansas and the type of practices on the farm.

The Role of Peer Irrigators on the Choice and Intensity of Use of Irrigation Techniques

Noah Hayward[*] *and Kent Kovacs*[†]

Abstract

The use and the proportion of farmland that uses prominent irrigation practices in Arkansas were evaluated. A bivariate sample selection model evaluated the determinants of the share of irrigated land in a farm that uses each practice. In addition, the relationship between the irrigation practices a peer uses and the use and intensity of five common irrigation practices was evaluated. If a peer of an Arkansas farmer used center pivot irrigation, this increased the probability that the farmer used center pivot irrigation by 66 percentage points. A peer that used pivot irrigation decreased the proportion of irrigated land that used flowmeter by 0.05. However, a peer using computerized hole selection increased the proportion of irrigated land on a farm using irrigation scheduling by 2.20. The peer effect variables were modeled with interactions for location and farm practices of a farm to examine heterogeneity in the peer relationship. A peer using computerized hole selection increased the likelihood a farmer used computerized hole selection by 55 percentage points, but if the farmer is in the south Arkansas Delta, the likelihood of using the practice increased an additional 60 percentage points. The irrigation practices in use by Arkansas farmers' families and friends affect the decision to use and the proportion of irrigated land that uses center pivot, scientific scheduling, and computerized hole selection.

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Introduction

Agriculture is responsible for roughly 80% of ground and surface water consumption in the United States (USDA, 2019). The adoption and diffusion of modern irrigation technologies can result in many beneficial factors such as reducing costs for farmers and preserving our natural resources. More efficient irrigation practices can reduce consumptive water use and may lower aquifer overdraft. Through modern irrigation technologies, farmers improve consumptive efficiency, which allows more of the water applied to reach the crop. Social learning influences irrigation technology use and how prevalent peer influence is within farming communities in Arkansas. By examining how peers influence farmers' decisions to use a certain irrigation practice, policymakers may better understand what irrigation practices promote irrigation efficiency.

Five of the irrigation practices in use by agricultural producers in the Lower Mississippi River Basin of Arkansas are scientific irrigation scheduling, flowmeters, center pivot, computerized hole, and surge (short definitions of these irrigation practices are in Table 1). Social learning affects the use of each irrigation practice and the proportion of land on the farm that utilizes that irrigation practice. Our measure of social learning refers to whether a farmer has a friend or family member that used one or more of twelve different irrigation practices in the last ten years.

Social learning is one way to receive information about irrigation practices (Genius et al., 2014; Conley and Urdy, 2010; Sampson and Perry, 2019). Genius et al. (2014) find that social learning and extension services synergistically increase farmers' knowledge and reduce the time to adoption of drip irrigation (Genius et al., 2014). Conley and Urdy (2010) find that pineapple producers in Ghana make decisions on input use levels based on whether the input use of a peer in a previous year was a success or failure. Other factors that determine irrigation practice use include farm characteristics and farmer demographics (Dridi and Khanna 2005). Economic factors (Schoengold and Sunding, 2014) (e.g., water price, cost of agriculture technology, farmers income, etc.) and farm characteristics (Genius et al., 2014) (e.g., farm size, soil type, location) and farmer demographics (Genius et al., 2014) (e.g., age, education) also play a part in the diffusion of modern irrigation.

The agricultural economy in Arkansas depends on irrigated crops such as cotton, soybeans, and rice. Arkansas contributes 49% of all rice production in the United States (USDA-ERS, 2019). The yield maximization of these crops depends on proper irrigation at all stages of plant growth. Currently, only about 60% of applied water reaches the intended crop, and policymakers recommend more efficient irrigation practices to reduce run-off and evaporation (ANRC, 2014).

Materials and Methods

Mississippi State University Social Science Research Center administered the survey via phone interviews. Prospective survey respondents were from the water user database being managed by the Arkansas Natural Resource Commission and all commercial crop growers identified by Dun & Bradstreet records for the state of Arkansas. More than 600 farmers reached by phone for the survey were eligible. However, two-fifths of eligible farmers declined to participate, and one-third discontinued the survey in progress. The response rate was ultimately 32%, with 199 fully completed surveys by producers (Rosene, 2019). The questionnaire had about 150 questions and took respon-

Table 1. Dependent variables for the model of the use of an irrigation practice.

Variable	Definition	Percentage
Scheduling	=1 if use scientific scheduling through soil moisture sensors, atmometers, or woodruff charts	0.123
Flowmeters	=1 if use flow meters to measure irrigation water applied to a field	0.352
CHS	=1 if uses computer hole selection with a computer software program to determine the diameter of the hole cut into a poly-pipe	0.347
Pivot	=1 if use center pivot to draw water from the ground at a central "pivot" and a sprinkler system rotates circularly, spraying water over the crops	0.376
Surge	=1 if use surge pulses water down furrows by diverting water to the left and right via valve movement	0.188

dents on average 30 to 40 minutes to complete through telephone. The definitions and summary statistics of the dependent variables for the use of each of the irrigation practices modeled are in Table 1, and the definitions and summary statistics of dependent variables for the share of land in each irrigation practice modeled are in Table 2. The definitions and summary statistics for the explanatory variables to predict the use and share of land in the irrigation practices are shown in Table 3.

A bivariate sample selection model was used to find the factors that correlated with the use of an irrigation practice and the proportion of land on a farm that used the practice (Cameron and Trivedi, 2005). A sample selection model is used because we want to understand what explanatory factors influence the proportion of land using an irrigation practice for all farmers rather than only the farmers already using the practice. The bivariate component refers to a dependent variable for a use equation and a dependent variable for the proportion of land equation. The use equation's dependent variable was binary to specify the use of an irrigation practice, and the proportion of land in an irrigation practice was the continuous dependent variable for the other equation.

The dependent variable in the use equation, y_1, was an incompletely observed value of a latent dependent variable y_1^*, where the observation rule was,

$$y_1 = \begin{cases} 1 \; if \; y_1^* > 0, \\ 0 \; if \; y_1^* \leq 0 \end{cases}$$

and the proportion of land equation was such that

$$y_2 = \begin{cases} y_2^* \; if \; y_1^* > 0, \\ - \; if \; y_1^* \leq 0. \end{cases}$$

This model indicated that y_2 was observed when $y_1^* > 0$, and y_2 did not take on a value when $y_1^* \leq 0$. The latent variables y_1^* and y_2^* specify that the use and proportion of land in each practice were not observed for the population as a whole. This then specified a linear model with additive errors for the latent variables, so

$$y_1^* = x_1'\beta_1 + \varepsilon_1,$$

$$y_2^* = x_2'\beta_2 + \varepsilon_2.$$

Bias in the estimation of β_2 would arise if $\varepsilon_1$and ε_2 were correlated.

Maximum likelihood was used for this estimation, which is asymptotically efficient, and used the additional assumption that the correlated errors were joint normally distributed and homoscedastic with

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \sim \aleph \left[\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix} \right].$$

The bivariate sample selection model used the likelihood function

$$L = \prod_{i=1}^{n} \{\Pr[y_{1i}^* \leq 0]\}^{1-y_{1i}} \{f(y_{2i} \mid y_{1i}^* > 0) \times Pr[y_{1i}^* > 0]\}^{y_{1i}}$$

where the first term came from the use equation when $y_{1i}^* \leq 0$, and the second term corresponded to the proportion of land equation when $y_{1i}^* > 0$. A likelihood ratio (LR) test with a Chi-squared statistic was used to determine whether the bivariate sample selection model was necessary for unbiased estimation of the coefficients for the explanatory variables on the proportion of irrigated land using an irrigation practice.

Results and Discussion

The marginal effects for the explanatory variables that relate to the irrigation practices of a farmer's peers on the use of flowmeters, pivots, computerized hole selection, and surge are in Table 4. If a peer used a flowmeter for irrigation, the likelihood of using a flowmeter by the farmer increased by 64 percentage points. However, if a peer used flowmeters in the ridge area, the likelihood of using flowmeters increased by only 19 percentage points (0.64 – 0.45 = 0.19). Likewise, if a peer used flowmeters and the producer is in the north Arkansas delta, the likelihood of using flowmeters increased by only 27 percentage points (0.64 – 0.37 = 0.27). These results show that the influence of peers on an agricultural producer's irrigation practices differs across the Arkansas region. If a peer used pivots for irrigation, the likelihood of a farmer

Table 2. Dependent variables for the model of the share of land in an irrigation practice.

Variable	Definition	Mean	Std. Dev	10th Percentile	90th Percentile
Share_Sched	Share of land that uses scientific scheduling	0.044	0.17	0	0.05
Share_FM	Share of land that uses flowmeters	0.089	0.20	0	0.31
Share_CHS	Share of land that uses computerized hole selection	0.107	0.22	0	0.45
Share_Pivot	Share of land that uses center pivot	0.085	0.21	0	0.30
Share_Surge	Share of land that uses surge irrigation	0.021	0.097	0	0.04

Table 3. Explanatory variables for predicting the use and share of land in irrigation practices.

Variable	Definition	Percentage
PeerPivot	=1 if peers[a] used center pivot	0.65
PeerSurge	=1 if peers used surge irrigation	0.36
PeerCHS	=1 peers used computerized hole selection	0.56
PeerFlowMeter	=1 if peers used flowmeters on the wells	0.65
PeerTWR	=1 if peers used tailwater recovery system	0.71
PeerZeroGrade	=1 if peers used zero grade leveling	0.75
PeerEndBlock	=1 if peers used alternate used end blocking, cutback irrigation, or furrow diking in irrigation	0.55
PeerAltWetDry	=1 if peers used alternate wetting and drying for rice irrigation	0.35
PeerCHS*Fin	=1 if peers used computerized hole selection and primary reason for adoption of tailwater recovery and reservoirs was financial assistance	0.05
PeerFM*Ridge	=1 If peers used flow meter and located in ridge	0.20
PeerFM*ND	=1 if peers used flow meter and located in North Delta	0.04
PeerCHS*SD	=1 if peers used computerized hole selection in the South Delta	0.03
PeerTWR*GP	=1 if peers used tailwater recovery systems in the Grand Prairie region	0.19
PeerTWR*Fin	=1 if peers used tailwater recovery system and primary reason for adoption of tailwater recovery and reservoirs was financial assistance	0.06
PeerTWR*RegCons	=1 if peers used tailwater recovery system and participated in regional conservation partnership program	0.11
Crop types		**Percentage**
IrrSorghum	=1 if grows irrigated sorghum	0.07
IrrCotton	=1 if grows irrigated cotton	0.14
Socioeconomic characteristics		**Percentage**
AgEdu	=1 if formal education related to agriculture	0.59
IncMid	=1 if household income between $75K and $200K	0.42
IncHigh	=1 if household income greater than $200K	0.13

[a] Peers include family members, friends, or neighbors using technology within the past 10 years.

using pivot irrigation increased by 66 percentage points. If a peer used computerized hole selection (CHS) for irrigation, the likelihood of a farmer using computerized hole selection increased by 55 percentage points. Having a peer that used computerized hole selection in the south Arkansas delta increased the likelihood of a farmer using computerized hole selection to 115 percentage points (0.55 + 0.6 = 1.15). This result is further evidence that peers' influence on the choice of irrigation practice can differ by geographic region.

Having a peer that used surge irrigation increases the likelihood that a farmer used surge by 9 percentage points. However, if the farmer lived in the Grand Prairie, then having a peer that used surge irrigation increased the likelihood the farmer used surge by an additional 47 percentage points. If the farmer lived near Crowley's Ridge, having a peer that used surge irrigation increased the chance the farmer used surge by 24 percentage points. The location of the farmer's residence had a significant influence on whether having a peer using surge would lead to the farmer using surge themselves. The investigation of the reasons for the dramatic variation across locations is a direction for future research. If a farmer used zero grade leveling, having a peer that used surge irrigation decreased the likelihood the farmer used surge by 15 percentage points. This suggested there is a substitution between field management practices, like zero grading in use for rice, and water flow control practices such as surge for row crops. Table 4 also shows the marginal effects for the type of crops grown on the farm to explain the use of an irrigation practice. A producer that cultivated sorghum was 45 percentage points more likely to use pivot, and a producer that cultivated cotton was 24 percentage points less likely to use flowmeters and 80 percentage points more likely to use pivot.

Marginal effects for explaining the proportion of irrigated land that used an irrigation practice appear in Table 5. The significant Chi-squared statistic indicated that the bivariate sample selection model was necessary for unbiased estimates of the coefficients on the explanatory variables predicting the share of irrigated land that uses scientific scheduling, flowmeters, and CHS. Having a peer that used CHS increased the proportion of irrigated land a farmer used for scientific scheduling by 2.2. Having a peer that used a flowmeter increased the proportion of irrigated land a farmer used for flowmeters by 0.33. Having a peer that used center pivot increased the proportion of land a farmer used for pivot by 0.18. Having a peer that used alternate wetting and drying or end blocking decreased the proportion of irrigated land in center pivot by 0.23 and 0.22, respectively. Having a peer that used computerized hole selection increased the proportion of irrigated land a farmer used for computerized hole selection by 0.17.

Table 4. Marginal effects for the peer and crop type variables to explain the use of an irrigation practice.

Variable	Flowmeters	Pivot	CHS	Surge
PeerPivot		0.66 (0.0) a		
PeerCHS			0.55 (0.00) a	
PeerFlowmeter	0.64 (0.00) a			
PeerCHS*SD			0.6 (0.05) c	
PeerCHS*Fin			0.82 (0.02) b	
PeerSurge				0.09 (0.46)
PeerSurge*GP				0.47 (0.01) a
PeerSurge*Ridge				0.24 (0.06) c
PeerZeroGrade				-0.15 (0.037) b
PeerFM*Ridge	-0.45 (0.048) b			
PeerFM*ND	-0.37 (0.063) c			
IrrSorghum		0.45 (0.009) a		
IrrCotton	-0.24 (0.087) c	0.8 (0.0) a		
Pseudo R^2	0.28	0.42	0.42	0.53

a – 1%, b – 5%, c – 10% significance. *P*-values from the probit model estimates in parentheses. There are 222 observations for each model of irrigation practice use.

A producer that had formal education related to agriculture had a 1.15 higher proportion of irrigated land that uses scheduling. A producer that had a household income between $75,000 and $200,000 had a 0.95 higher proportion of irrigated land that used scheduling than a producer with a household income of less than $75,000. A producer that had a household income greater than $200,000 had a further 0.86 higher proportion of land that uses scheduling. A producer that grew irrigated sorghum had a 0.12 higher proportion of land that used pivot. A producer that grew irrigated cotton had a 0.23 higher proportion of land that used pivot.

A peer using tail-water recovery (TWR) increased the proportion of irrigated land using surge by 0.05. A peer using TWR resulted in the farmer located in the Grand Prairie using a lower proportion of irrigated land with surge (-0.24). A farmer that received financial assistance for TWR or reservoirs and had a peer who used TWR also had a lower proportion of irrigated land with surge (-0.17). However, a farmer that participated in a regional conservation program and had a peer using TWR increased the proportion of land under surge by 0.13. The results for the proportion of irrigated land that used surge illustrated the heterogeneous effect of having a peer that used TWR.

There appeared to be complementarities and substitutions among irrigation practices witnessed through the peer effects. For example, a farmer with a peer that uses CHS increased the proportion of land in scheduling by 2.20. A farmer with a peer using pivot or end blocking resulted in a farmer increasing the proportion of their land using scheduling by 1.09 and 0.62, respectively. These results indicate how CHS, pivot, or end-blocking can be used together with scheduling to increase greater irrigation efficiency and suggests the irrigation practices farmers view as complements for their fields. If a farmer had a peer using surge or precision leveling, this lowered the proportion of land being irrigated with flowmeters. There can also be substitution among the irrigation practices as well that farmers use to achieve irrigation efficiency.

There appeared to be a relationship between pivot irrigation and the crops being produced. A producer cultivating sorghum increased the proportion of land using pivot by 0.12. A producer cultivating cotton increased the

Table 5. Marginal effects for the peer, crop type, and socioeconomic variables to explain the share of land that uses an irrigation practice.

Variable	Share_ Sched	Share_FM	Share_Pivot	Share_CHS	Share_Surge
PeerPLevel		-0.18 (0.06) c			
PeerSurge		-0.130 (0.02) b			
PeerCHS	2.2 (0.015) b			0.17 (0.06) c	
PeerFlowMeter		0.33 (0.00) a			
PeerPivot	1.09 (0.00) a		0.18 (0.05) b		
PeerAltWetDry			-0.23 (0.06) c		
PeerEndBlock	0.62 (0.084) c		-0.22 (0.014) b		
PeerTWR					0.05 (0.70)
PeerTWR*GP					-0.24 (0.09) c
PeerTWR*Fin					-0.17 (0.05) b
PeerTWR*RegCons					0.13 (0.04) b
IrrSorghum			0.12 (0.085) c	-1.46 (0.025) b	
IrrCotton	-1.4 (0.00) a	-0.19 (0.04) b	0.23 (0.065) c		
AgEdu	1.15 (0.01) b		0.18 (0.005) a		
IncMid	0.95 (0.002) a				
IncHigh	0.86 (0.00) a				
Pseudo R^2	0.76	0.10	0.14	0.09	0.09
LR test- Chi-squared statistic	16.12 a	63.49 a	1.15	9.49 a	1.85
Number of observations	59	81	30	40	52

a – 1%, b – 5%, c – 10% Significance. The *P*-values from the bivariate sample selection model estimates in parentheses. The significance of the Chi-squared statistic for the LR test for scheduling, flow meters, and CHS indicates the bivariate sample selection model is necessary for unbiased estimation of the coefficients on the explanatory variables.

proportion of land using pivot by 0.23. Producers with a formal agriculture education irrigated a higher proportion of their land with scientific scheduling and center pivot. Pivot and scheduling both involved the use of sophisticated equipment, and a formal education may allow them to better utilize newer and advanced practices. Farm income only influenced the proportion of irrigated land that uses scientific scheduling, perhaps because only farms with high income were willing to take a risk on new irrigation technologies.

Conclusions

Social learning through the knowledge of the irrigation practices in use by friends and family influenced Arkansan farmers' use of five common irrigation practices. In addition to examining if a farmer's social learning led to the use of an irrigation practice, the proportion of land irrigated with the irrigation practice is considered as well. A peer's use of center pivot had the greatest impact on a farmer using center pivot themselves. A peer's use of an irrigation practice differed substantially by location within Arkansas and the type of practices an agricultural producer already has on their farm.

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Exploring How Maternal Phosphorus Status Affects Calf Growth and Performance

Meet the Student-Author

Elizabeth Lafferty

I am originally from Rosston, Arkansas, where I grew up on a small cattle farm helping out where my dad would let me. From these experiences, I developed a passion for large animals. I began my undergraduate career at the University of Arkansas as a major in Animal Sciences with a preprofessional concentration. I was a member of the pre-vet club and an active volunteer at local animal shelters throughout my college years. I have also had the opportunity to gain hands-on experiences through my research and work as a veterinary technician. In February of 2020, I began my research on beef nutrition. I graduated Cum Laude and plan to obtain my doctor of veterinary medicine degree. My time at the University of Arkansas has been made possible by many individuals. I would like to thank Dr. Beth Kegley for serving as my honors mentor and for her confidence in me and continual support throughout this project. I also would like to thank Dr. Jeremy Powell and Dr. Brittni Littlejohn for serving on my thesis committee and for their help throughout this process. To my family, thank you for your continual encouragement and support while achieving my goals.

Elizabeth stands next to the centrifuge that is used to process blood samples. It was generously funded by the Honors Program Equipment Grant.

Research at a Glance

- Phosphorus is an important mineral in beef cattle nutrition and is thought to be linked to calf growth and performance.
- Data did not show any negative effects of supplementing excess phosphorus in free-choice minerals but was not advantageous in regard to calf growth or performance.
- Producers in the area where pastures have been fertilized with livestock manure could purchase minerals with or without phosphorus.

Exploring How Maternal Phosphorus Status Affects Calf Growth and Performance

Elizabeth Lafferty,[*] *Beth Kegley,*[†] *Brittni Littlejohn,*[§] *and Jeremy Powell*[‡]

Abstract

Phosphorus is an important component of bodily functions and is critical for adequate growth and development. This experiment evaluated the effect of maternal phosphorus intake on the growth and health of the calves. Treatments were 1) a free-choice mineral containing no supplemental P or 2) a free-choice mineral with 4% supplemental phosphorus. Primiparous, or pregnant for the first time, crossbred Angus beef cows (n = 36) were stratified by body weight and pregnancy status (bred by artificial insemination or natural service) then assigned to pasture groups (4 groups, 2/treatment, 9 heifers/group). These bred heifers had been receiving these same dietary treatments from 30 days after weaning until confirmation of pregnancy. Eighteen bred heifers from each treatment were selected randomly to continue into this experiment. At calving, colostrum and blood samples were collected from a subset of 12 heifers/treatment (6/group). Body weights were obtained for all cattle. Data were analyzed using the MIXED procedure of SAS. Cows grazed mixed grass pastures; monthly forage samples ranged from 0.28% to 0.36% P. There were no differences ($P > 0.10$) for cow body weight during gestation, calf birth weight, or calf weight at an average age of 21 days. There were also no differences ($P > 0.10$) in colostrum components (fat, protein, lactose, and IgG) or in the serum IgG or plasma mineral concentrations for both cows and calves 48 hours after birth. All calves were sampled at approximately 21 days of age, and there were no treatment differences ($P > 0.10$) in serum IgG concentrations. There were no benefits to supplementing gestating heifers with phosphorus when they grazed pasture with a history of fertilization with livestock manure.

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Introduction

The beef cattle industry is always looking for ways to increase gain performance and improve the fertility of developing heifers and cows. The goal of this study is to evaluate phosphorus supplementation on primiparous (or pregnant for the first time) cows and the effect on colostrum quality, calf growth, performance, and health. Colostrum is one of the main sources of minerals for newborn calves, especially calcium and phosphorus (Kume and Tanabe, 1993). In dairy calves, colostrum with high immunoglobulin concentrations led to weight gain in calves from birth to four days old, while low immunoglobulin concentrations led to weight loss (Nocek et al., 1984). If the same rationale can be applied to beef cattle, high immunoglobulin concentrations will increase weight gain during the first 4 days of life. Similar to immunoglobulin concentrations, colostrum with greater mineral content, phosphorus included, led to a decrease in calf mortality (Salih et al., 1987). Therefore, an increase in minerals, including phosphorus, could lead to greater immunoglobulin concentrations and, in return, an improved immune response and increased calf survival rate.

While phosphorus could lead to improved immune response and increased calf survival rate, phosphorus supplements may have a negative impact on the environment. When over-supplementation occurs, many nutrients are passed into the environment through manure and then into water sources. This process is unsustainable as it can ruin water sources for future farming and/or cities. Such is stated by researchers from the University of Nebraska's Department of Animal Science, "removal of phosphorus supplements are important nutritional management options to help feedlots become more environmentally sustainable" (Klopfenstein and Erickson, 2002). As phosphorus is introduced to water systems, algae begin to grow at an increased rate. Many water ecosystems are not readily prepared to counteract the increased growth rates of algae, and it leads to decreased oxygen levels in the water, thus lowering the water quality and the amount of aquatic life that can be supported in that body of water. Therefore, this experiment investigated the effect of maternal phosphorus intake on the growth and health of the calves.

Materials and Methods

The following procedures were reviewed and approved by the University of Arkansas Animal Care and Use Committee (IACUC) before the project began. For this experiment, heifers (n = 64) weaned in May 2019 from the University of Arkansas System Division of Agriculture's Experiment Station Beef Cow/Calf Research Unit near Fayetteville were used. Approximately 30 days after weaning, heifers were weighed, stratified by body weight, and divided randomly into 8 groups (8 heifers/group). Each group was then assigned randomly to one of two dietary treatments (Table 1): 1) supplemented with phosphorus (4% in a free-choice-mineral mix) and 2) not supplemented with phosphorus in an otherwise identical free-choice-mineral mix formulated to meet all other mineral and vitamin requirements. Heifers were allowed to graze 8 mixed grass pastures (2.4 ha each) and received supplemental soybean hulls (0.5% of body weight each day adjusted after each weigh day). Soil phosphorus concentrations in pastures ranged from 130 to 259 mg/kg of soil.

In November of 2019, heifers were synchronized and bred by artificial insemination (AI), followed by natural service. Data were collected by H. Hilfiker for her University of Arkansas Honors research project at that time and have been previously reported (Hilfiker, 2020). In February 2020, a portion of the heifers with a confirmed pregnancy continued onto this trial. Bred heifers were stratified by body weight and reassigned randomly within treatment to 1 of 2 groups (9 heifers/group). Each treat-

Table 1. Composition of free-choice mineral mixes used to deliver dietary treatments.

Ingredient	Control	Supplemental P
Calcium, %	20	20
Phosphorus, %	0	4
Salt, %	24 to 26	24 to 26
Magnesium, %	0.2	0.2
Potassium, %	0.1	0.1
Copper, mg/kg	2,500	2,500
Selenium, mg.kg	26	26
Zinc, mg/kg	10,000	10,000
Vitamin A, IU/kg	440,000	440,000
Vitamin D3, IU/kg	22,000	22,000
Vitamin E, IU/kg	22	22

ment had a similar number of heifers, 18, confirmed pregnant by either artificial insemination or natural service, and had similar average body weight. Pregnant heifers continued receiving the same dietary treatment to which they were originally assigned. Available forage, hay (when offered), and soy hulls were sampled monthly.

The heifers began calving in August of 2020. Two weeks prior to the anticipated calving date, heifers were moved nearer the working facility to smaller (0.45 ha) grass lots. A subset of heifers (12 heifers/treatment, 6 heifers/group) were selected for additional sample collection. At the time of birth, a pooled colostrum sample from all four quarters was collected from each of these heifers. The colostrum samples were evaluated for the following: 1) colostrum phosphorus concentrations and other minerals, 2) colostrum immunoglobulin G (IgG) concentrations, and 3) percentages of fat, protein, lactose, ash, and solids not fat, and a somatic cell count. Subsamples of colostrum were frozen at -20 °C for later mineral and immunoglobulin analyses, and a subsample for proximate analysis was placed in a sample vial provided by the commercial lab that contained a pellet of preservative, mixed thoroughly, and stored at room temperature until shipped to the Mid-South Dairy Records Laboratory (Springfield, Missouri).

At 48 hours after birth, blood samples were collected from these cows and calves by jugular venipuncture. Blood for the serum to be used to evaluate IgG concentrations was collected in vacuum tubes with a clot-activating compound. Blood for plasma mineral determinations was collected in vacuum tubes manufactured for trace mineral determinations. Anticoagulated whole blood samples for complete blood count analysis were collected in vacuum tubes containing EDTA. Blood was refrigerated until centrifuged at 2,100 × g for 20 min, then serum and plasma were stored frozen at -20 °C. Whole blood was refrigerated for up to 48 hours before being evaluated for white and red blood cell values using an automated analyzer (HemaVet HV950; Drew Scientific, Miami Lakes, Florida).

All calves were weighed and bled at approximately 21 days of age. There were three sampling dates: 14 September, 2 October, and 21 October, and actual calf age ranged from 15 to 36 days of age. Blood was handled similarly, and serum was used to determine IgG concentrations.

Forage and supplement samples were composited and dried in a forced-air oven, then ground using a Wiley Mill (Thomas Scientific, Swedesboro, New Jersey) through a 1-mm screen. Mineral mix samples were dried but not ground. All samples were prepared for mineral analysis by standard procedures and analyzed by inductively coupled plasma spectroscopy (Model 3560, Applied Research Laboratory, Sunland, California) at the University of Arkansas System Division of Agriculture's Altheimer Laboratory (Fayetteville, Arkansas).

Colostrum and serum immunoglobulin concentrations were determined by commercial anti-bovine IgG radial immunodiffusion kits (Immunology Consultants Laboratory, Inc., Portland, Oregon). The intra-assay CV was 7.3%, and the inter-assay CV was 2.5%.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, North Carolina) with pen set as the experimental unit. Compound symmetry was specified as the covariance structure. For heifer data, treatment was the only fixed effect, and replicate was the random effect. For calf growth performance data, treatment was the only fixed effect, and replicate and sex were specified as random effects. Kenward Rogers was specified as the degrees of freedom selection method in the mixed procedure. Mineral intake data were analyzed as a repeated measure, and the model included treatment, period, and the treatment by period interaction. Non-normal data were log-transformed before further statistical analysis to improve normality. For the purpose of this study, $P < 0.1$ was considered significant.

Results and Discussion

In this study, both groups of heifers grazed similar pastures and were offered identical rations of soyhull pellets. Each group's treatment of 0% or 4% phosphorus was delivered via free-choice mineral. The mineral offered was designed for a 113 g/day intake. Of this offered amount, each heifer consumed approximately 100 g/day. There was no effect ($P = 0.46$) of treatment on average mineral intake, with control averaging 99 g/day and supplemental phosphorus averaging 90 g/day. However, there was a treatment × period interaction ($P = 0.01$; Fig. 1) for mineral intake with the greatest intake of mineral (121 g/day) by the control heifers in the final period of the trial.

First-calf heifers that are approximately 464 kg require 0.13% to 0.18% of their diet to contain phosphorus (dry matter intake) throughout gestation and lactation (Nutrient Requirement Tables, 2018). The phosphorus concentrations of the mineral provided to both treatments were well over the minimum requirements for gestating and lactating first-calf heifers (Table 2). The control group was offered 0.28%, while the phosphorus group was offered 3.44% phosphorus in the mineral supplements. In addition to the mineral mix, the forages, hay, and soyhull pellets contributed to phosphorus concentrations ensuring that heifers were well over their minimum requirements. The majority of the heifers' diet was supplied as forage. Each month of forage had phosphorus concentrations greater than the minimum requirements for each heifer.

Calves were weighed at birth and at approximately 21 days postpartum to evaluate calf performance and average daily gain (ADG). Actual calf ages ranged from 15 to 36 days of age. The expected ADG for fall calves is 1.4 kg/day (UA-

DA-CES, 2016). Calves from each treatment performed similarly.

Normal protein percentages of colostrum can range from 16.8% immediately following birth to 6.3% at 12 hours after calving. Percentages of fat composition are less volatile and change more slowly. For fat, normal ranges are from 6.7% to 4.4%. Normal lactose concentrations are 2.9% to 3.9% (Puppel et al., 2019). Data for fat, protein, and lactose percentages (Table 3) were within the normal ranges as defined above. There were no differences between the control and the phosphorus group for percentages of fat ($P = 0.58$), protein ($P = 0.23$), and lactose ($P = 0.20$). Normal IgG concentrations for colostrum should be about 48 mg/ml (Sellers, 2001). Cows on each treatment had normal and nonsignificant results ($P = 0.38$).

Normal colostrum phosphorus percentages are 0.235% (Puppel et al., 2019). The recorded phosphorus concentrations for both the control and the phosphorus group are below the presumed normal concentration with no significant difference (Table 4). However, there was a tendency ($P = 0.11$) for the phosphorus supplemented heifers to have greater phosphorus in their colostrum at the time of calving. Colostrum calcium concentrations varied between the two treatments ($P = 0.02$). Normal percentages of calcium in colostrum are 0.256 (Puppel et al., 2019). The control and the phosphorus treatments were both below this average. Excess P in the body interferes with calcium metabolism and could cause these lower than average per-

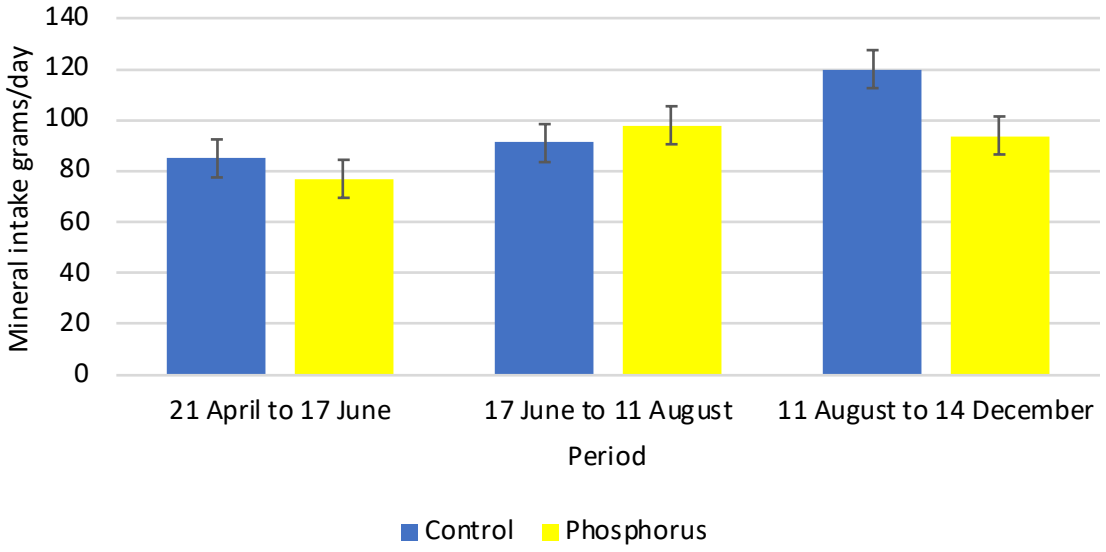

Fig. 1. Effect of phosphorus in the mineral offered on daily mineral intake as estimated by disappearance from the mineral feeders averaged across each period ($n = 4$, 2 groups/treatment; $P = 0.46$ for treatment and $P = 0.01$ for the treatment by period interaction).

Table 2. Mineral composition (DM basis) of minerals mixes, forage, hay, and soyhull pellets.

Feed	P	K	Ca	Mg	S	Na	Fe	Mn	Zn	Cu
	----------(%)----------						----------(mg/kg)----------			
Mineral with no added P	0.28	0.48	16.70	0.37	1.38	7.22	3,427	1,061	13,165	5,308
Mineral with supplemental P	3.44	0.30	16.36	0.24	1.07	7.11	6,213	1,091	8,197	4,760
Hay	0.36	1.58	0.49	0.38	0.14	0.03	72	162	57	6
Forage										
March, 2020	0.34	2.39	0.42	0.19	0.22	0.01	116	114	44	7
April, 2020	0.36	2.32	0.43	0.18	0.22	0.004	319	108	51	8
June, 2020	0.33	2.14	0.38	0.18	0.17	0.017	166	110	41	7
July, 2020	0.30	1.83	0.46	0.20	0.18	0.010	113	92	41	6
August, 2020	0.29	2.00	0.38	0.18	0.24	0.008	127	139	62	7
September, 2020	0.32	2.12	0.44	0.21	0.24	0.010	99	90	58	6
October, 2020	0.28	2.11	0.51	0.23	0.20	0.013	107	74	46	5
Soyhull Pellets	0.10	1.22	0.64	0.24	0.10	16.24	424	14	37	5

centages of calcium in the colostrum (Kidney Health Australia, 2017). However, it is unknown why the phosphorus-supplemented heifers colostrum calcium was greater than the control heifers.

The complete blood counts for the heifers were within normal limits and had no differences between heifers on the control and the phosphorus treatments (data not shown). All blood cell data for calves were within normal limits (data not shown), except for the percentage of red cell distribution width (RDW). The calves from the control treatment had RDW of 23.86%, while calves from the phosphorus treatment had 24.74% ($P = 0.04$). Varying data within the red cell distribution width can be caused by underlying anemia or iron deficiency, which can be explained due to collecting blood samples from young calves who have not yet received full passive immunity from colostrum [RDW (red CELL distribution WIDTH): Medlineplus medical test, 2020)]. Because no samples were taken later, it is unknown whether this difference remained; however, no calves were ever observed to be clinically anemic.

Normal IgG values in calves are 12.3 to 29.1 mg/mL at 24 hours after calving (Godden et al., 2009). At or before 12 hours postpartum, the calves from the control treatment and the phosphorus treatment had values within the parameters set above. The IgG concentrations of the calves from the control treatment and the phosphorus treatment at birth (Table 5) were similar ($P = 0.88$) and the IgG concentrations at day 21 had no significant difference ($P = 0.66$).

Normal cow plasma mineral concentrations of phosphorus are 5.6 mg/dL (McAdam and O'Dell, 1982). The heifers on the control treatment had 6.88 mg/dL of phosphorus, and heifers on the phosphorus treatment had 7.06 mg/dL. Heifers on both treatments had concentrations greater than average for phosphorus, likely because of the increased phosphorus concentrations in the pastures they were allowed to graze. While both concentrations were elevated, the heifers on the two treatments had no difference in phosphorus concentrations ($P = 0.62$). It is important to note that plasma magnesium concentrations for the heifers were different ($P = 0.02$). Heifers on the control treatment had magnesium concentrations at 2.58 mg/dL, and heifers on the phosphorus treatment had concentrations of 2.42 mg/dL. Normal magnesium concentrations are 2.01 mg/dL (McAdam and O'Dell, 1982). In general, as phosphorus concentrations in the diet rise, magnesium

Table 3. Effect of phosphorus concentration in the mineral offered to heifers on colostrum content.

Colostrum Components	Control	Phosphorus	Standard Error	*P*-value
Fat, %	5.05	5.93	--[a]	0.58
Protein, %	11.49	12.70	0.51	0.23
Lactose, %	3.06	2.58	0.18	0.20
Solids not fat, %	15.10	15.64	0.23	0.24
Somatic cell count, n x 1000/ml	7.24	7.20	--[a]	0.80
IgG, mg/ml	41	51	6.26	0.38

[a] Data were log transformed to improve normality, SE = 0.18 for the log-transformed percentage fat, and SE = 0.10 for the log-transformed somatic cell count.

Table 4. Effect of phosphorus concentration in the mineral offered on mineral concentrations in colostrum (n = 12/treatment).

Colostrum Minerals	Control	Phosphorus	Standard Error	*P*-value
Phosphorus, %	0.15	0.17	0.00	0.11
Potassium, %	0.14	0.12	0.01	0.36
Calcium, %	0.18	0.20	0.00	0.02
Magnesium, %	0.02	0.04	0.00	0.34
Sulfur, %	0.12	0.16	0.02	0.30
Sodium, mg/kg	891.92	1057.86	43.21	0.11
Zinc, mg/kg	22.90	35.28	3.79	0.14
Copper, mg/kg	0.10	0.13	0.01	0.23

Table 5. Effect of phosphorus concentration of heifers' colostrum on calf serum.

Colostrum Immunoglobulins	Control	Phosphorus	Standard Error (SE)	*P*- value
Birth IgG, % Log formation	19.0	19.6	--[a]	0.88
Day 21, % Log formation	11.0	12.0	--[a]	0.66

[a] Data were log transformed to improve normality, SE = 0.126 for the log-transformed birth IgG in ng/ml, and SE = 0.10 for the log-transformed IgG at day 21 in ng/ml.

retention decreases due to changes in electrolyte excretion by the kidney and absorption in the gut. Calf plasma mineral concentrations had no differences (data not shown).

Conclusions

The purpose of this study was to determine if the maternal phosphorus status of heifers affects the growth and performance of their offspring. Data collected over the course of this study indicates that offering phosphorus as a supplemental mineral to heifers throughout gestation does not affect the growth or performance of their calves. This study strongly indicates that when grazing forage is grown on soil that has adequate amounts of phosphorus, supplementation is not needed. Forages cattle grazed contained 0.28% phosphorus at minimum and 0.36% phosphorus at maximum, providing more than adequate levels of phosphorus for the heifers' diets. While offering minerals that include phosphorus has no negative effects on dams or calves, it is also not economically advantageous to farmers and may cause harm to the environment when used unnecessarily.

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The Effect of Whey Protein Supplementation at Breakfast on Tryptophan Levels, Food Intake, and Mood in Postmenopausal Women in a 16-Week Randomized Controlled Trial

Meet the Student-Author

Danielle Lamont

I graduated from Prairie Grove High School and am now a graduate of the University of Arkansas with a major in Human Nutrition and Dietetics, and a minor in Human Development and Family Sciences. I have been the recipient of several scholarships, including the Honors College Research Grant, the Honors College Academy Scholarship, the Arkansas Academic Challenge Scholarship, the University of Arkansas Alumni License Plate Scholarship, and the Albert and Mary Gartside Scholarship. As a graduate, I plan to earn experience in geriatric nutrition as a dietetic technician before obtaining a Master's in Human Nutrition and registration as a dietitian.

I would like to thank Dr. Jamie I. Baum, my Honors mentor and principal investigator for SHAPE. Without Dr. Baum, I would not have been able to have such a broad experience or have this experience at all. I would also like to thank Dr. Aubree Hawley, committee member, for sharing her knowledge and skill. I would also like to thank Dr. Kelly Webber, committee member, for her advice and expertise in the composition of this thesis. Thanks also to former graduate students Sam Walker and Angela Tacinelli for their advice, input, and leadership.

Danielle completing data entry work for her project from home.

Research at a Glance

- The Census Bureau estimates that by 2030, 25% of the United States population will be women ages 45 and up.
- Tryptophan levels, mood, and food intake were observed in postmenopausal women taking a whey protein supplement.
- There were no significant changes within the intervention group of 7 women. More research is needed.

The Effect of Whey Protein Supplementation at Breakfast on Tryptophan Levels, Food Intake, and Mood in Postmenopausal Women in a 16-Week Randomized Controlled Trial

Danielle L. Lamont[*] *and Jamie I. Baum*[†]

Abstract

Whey protein isolate supplementation has been recognized as having potential for regulating appetite, thereby potentially improving mood and food intake. The objectives of this project were to 1) analyze the effects of high-quality whey protein intake on overall diet and 2) identify and examine a correlation between tryptophan levels and mood regulation. This research was conducted using a randomized experimental design. A total of 13 postmenopausal women (12+ months after last reported menstrual cycle) were recruited and allocated to one of two dietary intervention (DI) groups: 1) control (maintain current lifestyle; CON; n = 6), and 2) whey protein isolate (WPI; 25 g; n = 7). Protein was consumed prior to 10:00 AM daily. Both interventions were followed daily for 16 weeks. All laboratory visits required participants to arrive fasted with complete 3-day dietary logs. Participants completed the Pittsburgh Sleep Quality Index (PSQI) and Profile of Moods Questionnaire. Height, weight, and waist-to-hip ratio were measured. A blood draw was administered to assess sleep and metabolic blood markers. A one-way repeated measures analysis of variance (ANOVA) was used to assess the differences in body mass index (BMI) and Profile of Mood States (POMS). One-way ANOVA was used to calculate the POMS Total Mood Disturbance scores. Clinical biomarker differences were determined through repeated-measures ANOVA (statistically significant: $P < 0.05$). Prism GraphPad Software v. 9.0 (La Jolla, California) was used for all analyses. Results were inconclusive. We found no correlation between daily whey protein isolate supplementation and tryptophan levels, overall diet, or mood regulation.

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[†] Jamie Baum, the faculty mentor, is an Associate professor in the Department of Food Science.

Introduction

The older adult population (≥65 years) in the United States is projected to double between 2017 and 2060 (Bureau, 2017). Two out of three older adults suffer multiple chronic diseases (The State of Aging and Health in America 2013, 2013). Additionally, in 2006, the Behavioral Risk Factor Surveillance System (BRFSS) indicated that in Arkansas, 8.6% to 12.4% of adults 50 years or older experienced depression (Directors, 2008). Depression can prevent successful treatment of chronic disease (Directors, 2008) and negatively impact overall diet through inducing unhealthy cravings (Chaput, 2014).

Projections estimate that by 2030, 25% of the United States population will be women ages 45 and up (Bureau, 2017). Postmenopausal women experience shifts in body composition, including an average 44% increase of visceral fat mass during menopause (Kozakowski et al., 2017; Panotopoulos et al., 1997), which may affect the way nutrients, such as tryptophan, are utilized. This population also experiences disrupted sleep cycles and fluctuating mood, partially due to hormone levels (Panotopoulos et al., 1997).

It is recommended to consume an evenly distributed, moderate amount of high-quality protein at each meal (Arentson-Lantz et al., 2015), but Western eating patterns are disproportionate, with breakfast providing a mere 16% of daily protein intake (Mishra et al., 2018). Furthermore, protein-containing foods consumed at breakfast are often of low protein quality (McCrory, 2014), resulting in inadequate consumption of essential amino acids (EEA) at the breakfast meal. This may contribute to low tryptophan levels and increased mood disturbances (Hoglund et al., 2019). Studies suggest that these factors may be reduced by whey protein supplementation (Wirunsawanya et al., 2018).

Whey protein isolate (WPI, 85% to 90% protein) (Flaim et al., 2017) has been associated with increased satiety (Hall et al., 2003), indicating that WPI may be useful in regulating appetite. The Recommended Dietary Allowance (RDA) of tryptophan for adults 19 years and older is 0.005 g/kg daily (Institute of Medicine, 2005). The RDA for this participant pool was approximately 0.3, 0.4, and 0.5 g/d for participants weighing 55.3, 73.4, and 91.5 kg, respectively. The Instantized BiPRO supplement used in this study contained approximately 0.8 g of tryptophan per 25 g daily serving. Therefore, this supplement provided tryptophan in amounts greater than the RDA for these participants.

Overall diet is influenced by sleep efficiency (Chaput, 2014). Tryptophan is the precursor to melatonin, which is involved in regulating the sleep-wake cycle (Peuhkuri et al., 2012). Insufficient sleep increases consumption of energy-rich foods to reduce psychological distress or relieve negative mood (Chaput, 2014). An increase in food intake, particularly high sodium- and carbohydrate-containing foods, contributes to the development of chronic disease (Zhou et al., 2016).

Tryptophan, also a precursor to the neurotransmitter serotonin, influences mood regulation, emotional processing, and alertness (Mohajeri et al., 2015). In a 19-day randomized-controlled trial, a test drink containing tryptophan was administered twice per day; researchers found improvements in emotional processing and reduced sensitivity to negative stimuli (Mohajeri et al., 2015). The results suggested that high levels of tryptophan supplementation improve mood and mitigate depressive episodes (Mohajeri et al., 2015).

The objectives of this project were to 1) analyze the effects of high-quality whey protein intake on overall diet and 2) identify and examine a correlation between tryptophan levels and mood regulation. We hypothesized that 25-g of whey protein isolate supplementation daily for 16 weeks would increase tryptophan levels, improve overall diet, and improve mood regulation in postmenopausal women.

Materials and Methods

Prior to subject recruitment, this study was approved by the University of Arkansas' Institutional Review Board and was registered on clinicaltrials.gov, clinical trial number: NCT0303041. Participants were recruited from July 2018 through April 2020.

Recruitment was ended earlier than anticipated due to the COVID-19 pandemic. Participants were recruited voluntarily through advertisements in the University of Arkansas' daily news email, social media, word-of-mouth, and flyers. Eligibility required that participants were postmenopausal women with a last reported menstrual cycle 12 months or more in the past; were not taking hormone replacement therapy (HRT); had no known food allergies; regularly ate breakfast (>5 times per week); were not taking medications that impact appetite, blood coagulation, metabolism, or blood lipids; were not regularly consuming protein supplements; were not consuming more than 0.8 g/kg of protein per day (assessed via food frequency questionnaire); and have an initial Pittsburgh Sleep Quality Index (PSQI) of 5 or greater, as this score indicated dysregulated sleep. All subjects completed a phone screening and signed an informed consent form prior to enrolling. Participants were recruited on a rolling basis and were randomly assigned a treatment group. A total of 13 women, ages 46 to 72, completed the 16-week study.

This research was conducted using a randomized experimental design. A total of 13 postmenopausal women (12+ months after last reported menstrual cycle) were recruited and allocated to one of two dietary intervention (DI) groups. The demographic of postmenopausal women was chosen to negate hormonal influence and to provide

data on a population with limited available research. Upon acceptance into the study, participants were assigned randomly to 1 of 2 dietary intervention (DI) groups. The DI groups were as follows: 1) control (maintain current lifestyle; CON; n = 6), and 2) whey protein isolate (WPI; 25 g; n = 7). Protein was consumed prior to 10:00 AM daily. Both interventions were followed daily for 16 weeks.

The WPI supplement, Instantized BiPRO (Davisco Foods International, Le Sueur, Minnesota), was given in 28 single-serving bags at the baseline, 4-, 8-, and 12-week laboratory visits. Participants were instructed to return empty supplement packages to the researchers upon the next visit to ensure compliance. All 5 laboratory visits required participants to arrive fasted with complete 3-day dietary logs.

Participants received a booklet corresponding to their randomly assigned intervention. All booklets contained a standard study day schedule and checklist, and breakfast recipes that were modified to include protein powder for those participants assigned whey protein.

Body composition was measured via DEXA at baseline and week 16. Height, weight, and waist-to-hip ratio were measured at baseline, 4-, 8-, 12-, and 16-weeks. Height was measured to the nearest 0.01 cm using a stadiometer (Detecto, St. Louis, Missouri) with participants barefoot in the free-standing position. Weight was measured to the nearest 0.01 kg using calibrated balance scales (Detecto, St. Louis, Missouri), with participants in the fasting state without shoes. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. Waist measurements were taken at the level of the umbilicus using a soft tape measure and were rounded to the nearest 0.1 cm. Hip measurements were taken at the widest point below the waist using the soft tape measure and were rounded to the nearest 0.1 cm. Waist-to-hip ratios were recorded by dividing the waist measurement (cm) by the hip measurement (cm).

At baseline, 4-, 8-, 12-, and 16-weeks, participants completed 3-day food records. Food data was recorded for two weekdays and one weekend day; for example, Sunday, Monday, and Tuesday, food data would be recorded prior to a Wednesday test day. Participants were trained to accurately record amounts of food using provided food scales (Greater Goods, LLC, St. Louis, Missouri) and beverages. Participants were asked to record brand names and food preparation methods. A researcher reviewed the 3-day food records with the participants on each study day to confirm details. The Nutrition Data System for Research (Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minnesota) analysis software was used to analyze the energy, micronutrient, and macronutrient composition of the 3-day food records.

Sleep was assessed at baseline, 8-, and 16-weeks, using the PSQI. The PSQI is validated as an instrument of subjective measure of sleep quality (Mollayeva et al., 2016).

Mood was assessed at baseline, 8 weeks, and 16 weeks, via the Profile of Mood States (POMS) questionnaire. The POMS questionnaire has been validated in postmenopausal women (Wyrwich and Yu, 2011). The questionnaire consists of 65 questions containing a one-word adjective of mood to measure and identify six affective states. Those states are tension, depression, anger, vigor, fatigue, and confusion. Participants define their mood on a 5-point Likert scale. Response options are 0 = not at all; 1 = a little; 2 = moderately; 3 = quite a lot; 4 = extremely. Researchers were available to answer questions regarding the meaning of a word.

The sum of the responses for each adjective is calculated to score each affective state subscale. Higher subscale scores for all except vigor represent a poor mood. The Total Mood Disturbance score (TMD) is determined through the summation of the scores of the six factors (weighting vigor negatively). The TMD is calculated by the following equation:

$$\text{TMD} = (\text{Tension} - \text{Anxiety}) + (\text{Depression} - \text{Dejection}) + (\text{Anger} - \text{Hostility}) + (\text{Fatigue} - \text{Inertia}) + (\text{Confusion} - \text{Bewilderment}) - (\text{Vigor} - \text{Activity})$$

A blood draw was administered by a certified phlebotomist to assess metabolic blood markers. Tryptophan (and all amino acids) was measured using the commercially available EZ Faast amino acid analysis kit via gas chromatography/mass spectrometry.

One-way repeated measures analysis of variance (ANOVA) was used to assess the differences in BMI and POMS. One-way ANOVA was used to calculate the POMS Total Mood Disturbance scores. Clinical biomarker differences were determined through repeated-measures ANOVA (statistically significant: $P < 0.05$). Prism GraphPad Software Version 9.0 (La Jolla, California) was used for all analyses. All measurements were reported as the mean ± standard deviation.

Results and Discussion

In this 16-week study, tryptophan levels, mood, and food intake were evaluated in order to determine the effect of whey protein supplementation on postmenopausal women. Though the study size was relatively small, any significant effects could lead to a deeper understanding of the impact of whey protein supplementation on the health of postmenopausal women.

There were no significant differences for plasma tryptophan concentrations with 16-weeks of protein supplementation (Fig. 1). There were also no significant mood regulation changes, as shown in Figs. 2 and 3. Current research indicates that high-quality protein supplementation can reduce mood disturbances and stress-related mental

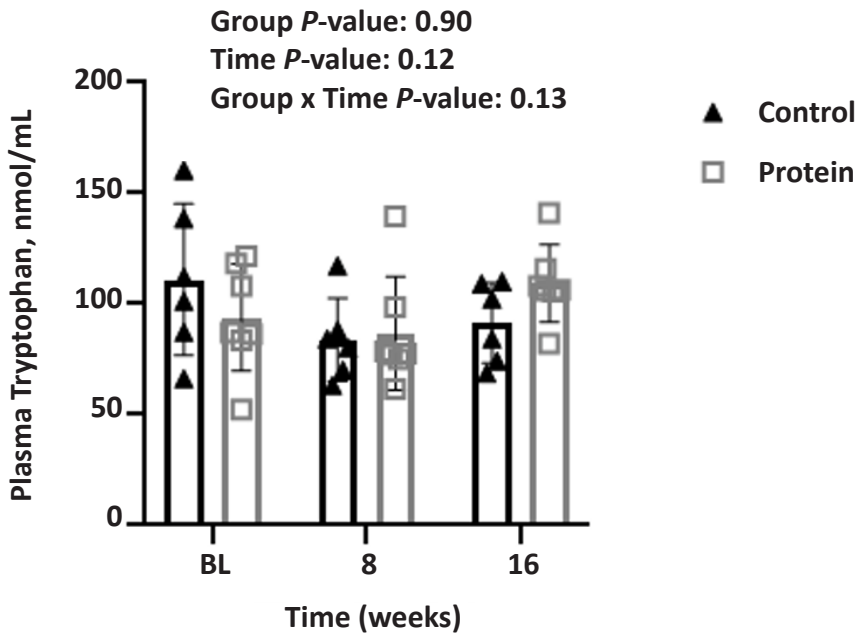

Fig. 1. Plasma tryptophan levels over the course of the intervention. Control, indicated by black triangles, represents the no intervention and free living group, n = 6. Protein, indicated by the gray squares, represents the whey protein isolate intervention group, n = 7. Plasma tryptophan levels for the control group lowered after baseline (BL) and increased after week 8. Plasma tryptophan levels for the protein group lowered slightly after baseline and increased after week 8. Significant differences: * $P < 0.05$. Results not significant.

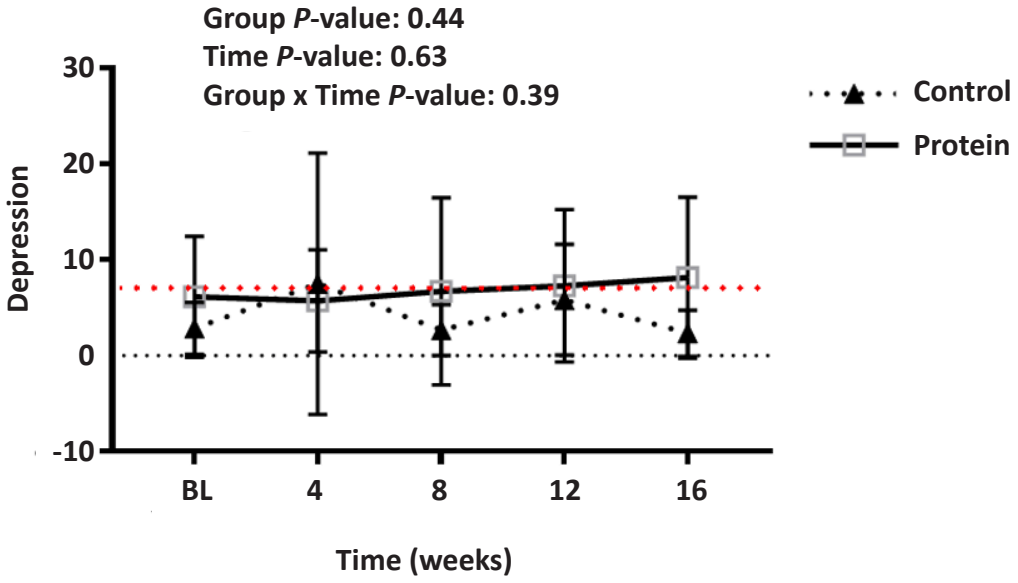

Fig. 2. Depression from baseline to 16 weeks. Control, indicated by black triangles, represents the no intervention and free living group, n = 6. Protein, indicated by the gray squares, represents the whey protein isolate intervention group, n = 7. Depression for the control group returned to baseline (BL) levels at weeks 8 and 16, rising at weeks 4 and 12. Depression for the protein group remained stable throughout the intervention. Significant differences: * $P < 0.05$. Results not significant

disorders (Hoglund et al., 2019; Wirunsawanya et al., 2018). Additionally, the literature suggests a positive impact of protein supplementation on overall mood through improving sleep efficiency (Chaput, 2014). Our results were incongruent, though the sample size may have been too small for statistically significant improvements. Aside from increasing sample size, the addition of exercise or nutrition education to the intervention may be necessary for more informative results.

Statistically significant results were found for protein intake; however, this would be expected since the intervention was a whey protein isolate supplement. These results are inconsistent with current literature, as some studies find significant results in regulating mood with protein supplements (Mohajeri et al., 2015); however, the composition of said supplements may be different from the Instantized BiPRO supplement used in this study.

Conclusions

Further research is necessary to determine a correlation between whey protein isolate and tryptophan levels, overall diet, and mood regulation in postmenopausal women. High-quality protein does appear to improve mood regulation; therefore, further research is needed.

Acknowledgments

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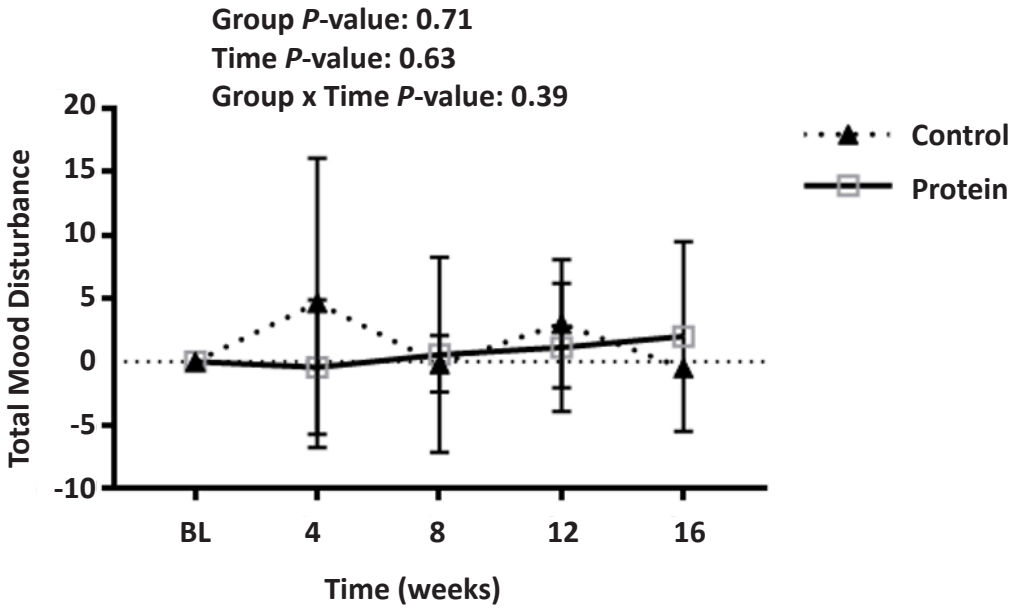

Fig. 3. Total Mood Disturbance from baseline to 16 weeks. Control, indicated by black triangles, represents the no intervention and free living group, n = 6. Protein, indicated by the gray squares, represents the whey protein isolate intervention group, n = 7. Total Mood Disturbance for the control group returned to baseline (BL) at weeks 8 and 16, rising at weeks 4 and 12. Total Mood Disturbance for the protein group remained mostly stable throughout, rising at week 16. Significant differences: * $P < 0.05$. Results not significant.

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Long-Term Changes in Soil Surface Properties as Affected by Management Practices in a Wheat-Soybean, Double-Crop System

Meet the Student-Author

Machaela Morrison

I grew up in West Fork, Arkansas, running around the woods and playing in the dirt. My family has a long line of University of Arkansas graduates, and I decided to follow in their footsteps. I will be graduating with Honors, a major in Environmental, Soil, and Water Science, and a minor in Biology. I spent my time at the University of Arkansas as part of both the Horticulture Club and the Crop, Soil, and Environmental Sciences Club. I also discovered my love for soil, and I was on the University of Arkansas soil judging team for three years. My team won first place twice, and we won the opportunity to travel to Nationals together. I'm very happy with the time I've spent as part of the Crop, Soil, and Environmental Sciences department, and next fall, I am starting my master's degree in Soil Science with Dr. Kris Brye as my mentor. I want to thank Dr. Brye for cultivating my love of soil and believing in my abilities as a researcher and writer. I also want to thank my thesis committee members, Dr. Lisa Wood and Dr. Dave Miller, for their guidance over these last four years.

Machaela at the National Soil Judging contest in San Luis Obispo, California, during practice days in April 2019.

Research at a Glance

- The wheat-soybean double-crop system is widely used throughout the mid-South, but the effects of the management practices used on soil properties is largely unknown.
- This long-term study observed the effects of burn/no-burn, tillage/no-till, and high-low residue levels across 0 to 10 cm and 10 to 20 cm soil depths from 2010 to 2020.
- Results of effects of management practices on soil organic matter, soil C, soil N, bulk density, and pH were widely varied.

Long-Term Changes in Soil Surface Properties as Affected by Management Practices in a Wheat-Soybean, Double-Crop System

Machaela L. Morrison and Kristofor R. Brye†*

Abstract

Long-term agricultural sustainability and productivity are controlled by the integrative effects of different management practices on the soil. Many Arkansas producers use the double-crop system to grow soybeans [*Glycine max* (L.) Merr] and wheat (*Triticum aestivum* L.). The objective of this study was to evaluate the effects of agricultural management practices, including residue level, tillage, irrigation, burning, and soil depth on the change in various soil properties from 2010 to 2020 in a long-term, wheat-soybean, double-crop system on a silt-loam soil (Glossaquic Fraglossudalfs) in eastern Arkansas. Soil nutrients tended to accumulate over time, the most in the top 10 cm, while soil nutrient contents in the 10- to 20-cm depth interval tended to not significantly change over time. Soil bulk density (BD) generally decreased across all treatments over time. Soil organic matter (SOM) content increased under all treatment combinations by 0.097 kg/ha. Soil BD decreased and SOM numerically increased the most in the no-till/no-burn treatment at the top 10 cm of the soil. Total carbon was 9.2 times greater, while total nitrogen was 48 times greater in the top 10 cm of the soil than the 10- to 20-cm depth. Soil pH was 1.9 times greater under irrigation than under non-irrigated treatments. Quantifying soil-property change over time will help producers to better understand the long-term effects of various residue and water management practices and to find reasonable, more sustainable alternative practices.

* Machaela Morrison is a May 2021 honors program graduate with a major in Environmental, Soil, and Water Science and a minor in Biology.

† Kristofor Brye, the faculty mentor, is a Professor in the Department of Crop, Soil, and Environmental Sciences.

Introduction

The wheat (*Triticum aestivum* L.)-soybean [*Glycine max* (L.) Merr] double-crop system has been common in the mid-South since after World War II and was adopted by many southern states, including Arkansas (Marra and Carlson, 1986). In 2020, approximately 1.14 million ha of soybeans and 58,679 ha of wheat were planted in Arkansas (NASS, 2021). Today, producers are focused on sustainability and conservation of water and soil resources, and it is important to monitor and study the effects of the various methods and treatments that producers may employ to grow their crops.

While using a double-crop system, many producers find it valuable to burn the wheat residue in between crops. Burning the residue provides the short-term benefits of weed control and preparing the seedbed for planting (Chan and Heenan, 2005). Despite the short-term advantages of residue burning, a study conducted in western Canada revealed there were no long-term benefits to burning the wheat residue (Biederbeck et al., 1980).

Conventional tillage (CT) and no tillage (NT) are two ways of preparing soil and managing surface residues for crop production. Conventional tillage involves plowing or other intensive tillage and leaves less than 15% residue coverage after planting. No tillage is a type of conservation tillage, where the soil is left undisturbed after a harvest. Conservation tillage leaves over 30% residue coverage at the time of seeding, while NT can leave up to nearly 100% surface coverage with residue (Padgitt et al., 2000), which can lead to a general increase in soil organic matter (SOM) and nutrients over time, at least in the upper several centimeters of the soil (Sanford, 1982).

The application of different levels of N fertilizer to the soil can result in varying levels of SOM and soil carbon. Brye et al. (2007) reported that SOM was greater in the no-burn/low-residue-level treatment combination and that soil C:N ratio was greater in the no-burn/high-residue-level treatment combination compared to the other burn-residue-level combinations.

Studying the effects of high- and low-residue levels, CT and NT, and burning and non-burning can help producers better understand not only the short-term effects these treatments have on soybean and wheat production, but also the long-term effects on soil physical and chemical properties and sustainability as well.

The objective of this study was to evaluate the effects of agricultural management practices, including tillage, residue level/fertility, residue burning, irrigation scheme, and soil depth, on the change in various soil properties over time (i.e., from 2010 to 2020) in a long-term, wheat-soybean, double-crop production system on a silt-loam soil in eastern Arkansas. It was hypothesized that soil bulk density (BD), SOM, and total carbon (TC) would increase over time under NT and no burning, and the increase over time would be greater in the 0- to 10-cm depth than under CT, burning, and in the 10- to 20-cm depth. It was also hypothesized that BD and pH would change over time across the different irrigation and burning treatments and that SOM, TC, and total nitrogen (TN) would increase over time more in the high- than in the low-residue-level treatment.

Materials and Methods

A long-term field study was initiated at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas, in 2001 (Cordell et al., 2006; Fig. 1). The study site consisted of 48 plots, with three replications of irrigation-tillage-residue burning-fertility/residue level treatment combinations. The soil at the field site is a Calloway silt loam (fine silty, mixed, active, thermic Glossaquic Fraglossudalfs) (Web Soil Survey, 2021). The 30-year mean annual air temperature and precipitation for the study area are 16.6 °C and 128 cm, respectively (NOAA, 2021). The mean monthly maximum and minimum air temperatures are 32.9 °C in July and -0.6 °C in January (NOAA, 2021).

Composite soil samples were manually collected at the end of the wheat-growing season (late May to early June) in 2010 and 2020 with a 4.8-cm-inside-diameter core chamber and slide hammer from the 0- to 10- and 10- to 20-cm depths in each plot. Cores were collected after wheat harvest but before tillage and soybean planting. After oven drying at 70 °C for 48 hours, soil samples were weighed for bulk density determination and then were ground and sieved through a 2-mm mesh screen for chemical analysis. Soil pH was determined using an electrode in a 1:2 (wt/vol) soil:water suspension. After 2 hours at 360 °C, soil organic matter (SOM) concentration was determined by weight-loss-on-ignition. Total soil C (TC) and N (TN) concentrations were determined by high-temperature combustion (LECO CN-2000 analyzer, LECO Corp., St. Joseph, Michigan, in 2010 and Elementar VarioMAX CN analyzer, Elementar Americas Inc., Ronkonkoma, New York, in 2020). Using the measured bulk density and 10-cm depth interval, SOM, TC, and TN measured concentrations were converted to contents and reported in units of Mg/ha.

In order to determine change over time, the 2010 data were subtracted from the 2020 data on a plot-by-plot basis. The change-over-time data were used for statistical analyses.

A four-factor analysis of variance (ANOVA) was conducted using SAS v. 9.4 (SAS Institute, Inc., Cary, North Carolina) to evaluate the effects of tillage, residue burning, fertility/residue level, soil depth, and their interactions on the change in soil properties from 2010 to 2020. When ap-

propriate, means were separated by least significant difference at the 0.05 level. Significance was judged at $P < 0.05$.

Results and Discussion

With the exception of soil pH, the change in all other measured or calculated soil properties over time were affected by at least one of the field treatments tested (i.e., tillage, fertility/residue level, and/or residue burning; Table 1). Averaged across tillage, fertility/residue level, and soil depth, the change in TN content over time was more than two times greater ($P = 0.02$; Table 1) under no burn (0.200 Mg/ha) than under burn (0.096 Mg/ha). However, soil TN content did not change over time from 2010 to 2020 in either burn treatment. The greater levels of TN under NB than B were likely at least partially due to the cumulative effects of crop residue retention on the soil surface when not burned that slowly contributed N to the soil as the residues decomposed and mineralization occurred, which were processes that could not have occurred to a similar magnitude when most of the surface residue was lost when burning occurred (Brye, 2012).

Averaged across tillage, fertility/residue level, and burn treatments, the change in soil TN content over time was also 46 times greater ($P < 0.01$; Table 1) in the top 10 cm (0.290 Mg/ha) than in the 10- to 20-cm soil depth interval (0.006 Mg/ha). Soil TN in the 10- to 20-cm depth changed significantly over time, whereas TN in the top 10 cm did not. Soil nutrients, and SOM and its constituents in general, commonly display vertical stratification, often exponentially decreasing with depth (Wright et al., 2007).

Soil BD numerically decreased over time, but the decrease over time differed ($P = 0.02$) among tillage-burn treatment combinations across soil depths (Table 1). Averaged across fertility/residue level treatments, the change in soil BD over time was numerically greatest in the CT-B

Fig. 1. Aerial view of the study site at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas.

treatment combination in the top 10 cm, which did not differ from that in the CT-NB and NT-NB treatment combinations in the top 10 cm. The change in soil BD over time was numerically lowest in the CT-B treatment combinations in the 10- to 20-cm soil depth, which did not differ from that in the CT-NB and NT-NB treatment combinations in the 10- to 20-cm depth (Fig. 2). Soil BD in all tillage-burn-soil depth treatment combinations, except for in the CT-B and the CT-NB treatment combinations in the 10- to 20-cm soil depth, decreased significantly over time from 2010 to 2020. The general decrease in bulk density was at least partially due to the cumulative effects of numerically increasing SOM (Norman et al., 2016), which promotes soil structure formation and greater porosity. Compared to NT, tillage quickly incorporates surface residues, OM, and C into the soil, and burning promotes quicker decomposition of belowground root biomass compared to non-burning. Results of this study were consistent with those reported by Sanford (1982) and Six et al. (1999). Similarly, Amuri et al. (2008) and Norman et al. (2016) reported an increase in bulk density in the top 10 cm under NT during the first six years and then the next eight years, respectively, of the current long-term field study.

Soil OM content in the top 10 cm of the NT-NB was the only treatment combination that significantly increased over time from 2010 to 2020, where SOM did not change over time in the other seven tillage-burn-depth treatment combinations (Fig. 2). However, the change in SOM content over time differed ($P < 0.01$) among tillage-burn treatment combinations across soil depths (Table 1). Averaged across fertility/residue level treatments, the change in SOM content over time was numerically greatest in the NT-NB treatment combination in the top 10 cm, which did not differ from that in the CT-B and CT-NB treatment combinations in the top 10 cm. The change in SOM over

Table 1. Analysis of variance summary of the effects of tillage, fertility/residue level, residue burning, soil depth, and their interactions on the change in soil bulk density (BD), pH, soil organic matter (SOM), total carbon (TC), and total nitrogen (TN) over time from 2010 to 2020 in a long-term, wheat-soybean, double-crop production system on a silt-loam soil in eastern Arkansas.

Treatment Effect	ΔBD	ΔpH	ΔSOM	ΔTC	ΔTN
Tillage (T)	0.92	0.12	0.36	0.57	0.77
Fertility (F)	0.59	0.17	0.13	0.46	0.67
T*F	0.97	0.25	0.12	0.26	0.29
Burning (B)	0.26	0.37	0.06	0.37	0.02
T*B	0.22	0.23	0.27	0.33	0.16
B*F	0.50	0.45	0.89	0.77	0.67
T*B*F	0.81	0.30	0.29	0.60	0.83
Depth (D)	< 0.01	0.31	< 0.01	< 0.01	< 0.01
T*D	< 0.01	0.18	0.48	0.69	0.67
F*D	0.54	0.51	0.60	0.57	0.17
T*F*D	0.59	0.61	0.61	0.18	0.60
B*D	0.37	0.25	< 0.01	0.03	0.06
T*B*D	0.02	0.21	< 0.01	0.05	0.14
B*F*D	0.68	0.62	0.39	0.62	0.34
T*B*F*D	0.46	0.65	0.66	0.31	0.17

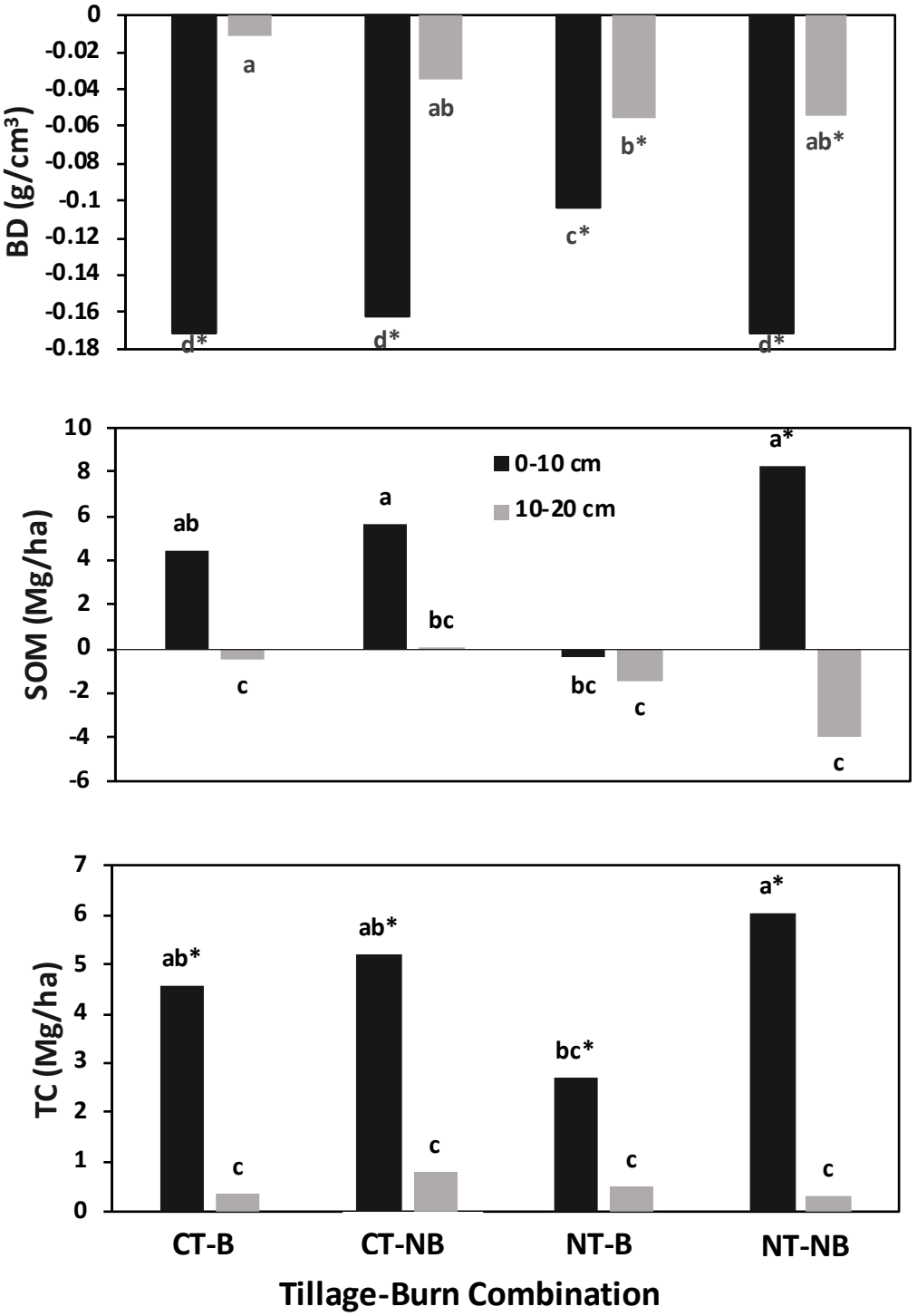

Fig. 2. Summary of the interactive effects of tillage [conventional tillage (CT) and no-tillage (NT)] and burning [burning (B) and non-burning (NB)] on the change in bulk density (BD), soil organic matter (SOM), and total carbon (TC) across soil depths over time from 2010 to 2020 in a long-term, wheat-soybean, double-crop production system on a silt-loam soil in eastern Arkansas. Positive values indicate an increase, while negative values indicate a decrease over time. Lower case letters atop bars within a panel are different at $P < 0.05$. Asterisks (*) indicate the mean change for a treatment combination differs from 0 at $P < 0.05$.

time was numerically lowest in the NT-NB treatment in the 10- to 20-cm soil depth, which did not differ from that in the NT-B and CT-B treatment combinations in the 10- to 20-cm depth (Fig. 2).

The increase in SOM in the NT-NB treatment in the top 10 cm was likely due to the organic matter that was allowed to accumulate on the soil surface. The NT treatment did not incorporate the crop residue into the soil, allowing the residue to decay and add OM to the top layer of the soil slowly. In the NB treatment, the crop residue also remained on the soil surface. Both the NT and NB treatments combined resulted in significantly increased SOM content in the top 10 cm. However, the SOM content in the NT-NB treatment in the top 10 cm did not differ from that in other field treatments. However, field treatments did not have the same effect in the 10- to 20-cm soil depth due to the lack of deeper residue incorporation into the soil. Results of the current study were similar to the results of Amuri et al. (2008), who reported that SOM content in the top 10 cm did not increase in any specific field treatment in the first seven years. Instead, SOM content in the top 10 cm generally increased over time across all treatments combined (0.097 kg/ha/yr). The same field treatments of the current long-term study SOM did not increase over time in any specific field treatment. Similarly, Norman et al. (2016) also reported an average increase in SOM (0.097 kg/ha/yr) in the top 10 cm across all treatments combined during years six through 14 in the same plots and same field treatments of the current long-term study.

In contrast to SOM, soil TC content, which was considered to represent all organic C (OC) since soil did not effervesce upon treatment with dilute hydrochloric acid, significantly increased over time from 2010 to 2020 in all four tillage-burn treatment combinations in the top 10 cm, but did not change over time in all four tillage-burn treatment combinations in the 10- to 20-cm depth interval (Fig. 2). However, the change in soil TC content over time (i.e., the SOC sequestration rate) differed ($P = 0.05$) among tillage-burn combinations across soil depths (Table 1). When averaged across fertility/residue level treatments, the SOC sequestration rate was numerically greatest in the NT-NB treatment combination in the top 10 cm, which did not differ from that in the CT-B and CT-NB treatment combinations in the top 10 cm, while the SOC sequestration rate was numerically lowest in the NT-NB treatment combination in the 10- to 20-cm depth, which did not differ from that in the CT-B, CT-NB, and NT-B treatment combinations in the 10- to 20-cm depth (Fig. 2).

Significant soil TC and SOC sequestration occurred in the top 10 cm in all field treatments in the top 10 cm because of the increase in SOM in the top 10 cm, which did not occur in the 10- to 20-cm depth. Soil OM contains a substantial fraction of C, often around 50% (NRCS, 2021); thus, when SOM breaks down, both TC and SOC tend to increase. These results are consistent with Amuri et al. (2008), who reported an increase in soil TC and SOC in the top 10 cm of the soil in the first seven years in the same plots and same field treatments of the current long-term study.

In contrast to all other measured or calculated soil properties, the change in soil pH over time was unaffected by tillage, burning, high (H) or low (L) fertility/residue level, or soil depth (Table 1). However, soil pH in several tillage-burn-fertility-depth treatment combinations changed significantly over time. When averaged across all field treatments, soil pH decreased over time in the NT-B-H ($P = 0.05$) and NT-B-L ($P < 0.01$) treatment combinations in the top 10 cm and in the NT-B-L ($P = 0.05$) treatment combination in the 10- to 20-cm depth, while soil pH did not change over time in the other 13 treatment combinations. The lower pH under residue burning than non-burning may be due to increased N mineralization and nitrification, which is an acidifying process. Burning allows for greater mineralization of residues, leading to increased nitrification. The process of nitrification releases H+ ions into the soil, which leads to greater acidity and lower pH (Amuri et al., 2008). However, Amuri et al. (2008) reported that, for the first six years of the current long-term study, the average pH in the top 10 cm increased over time across all treatment combinations. In contrast to Amuri et al. (2008), but similar to the results of the current study, Norman et al. (2016) reported that soil pH generally decreased across all treatment combinations between years 6 and 14 of the current long-term study.

Conclusions

This long-term study in the Lower Mississippi River delta region of eastern Arkansas revealed that different crop management practices have varying effects on near-surface soil properties. Soil properties, such as BD, SOM, TC, TN, and pH, were affected by various agricultural residue and water management practices (i.e., irrigation, tillage, and fertility/residue level treatments) that also varied across soil depths. In general, BD decreased over time in both soil depths but decreased more in the top 10 cm than in the 10- to 20-cm depth. As hypothesized, residue burning lowered soil nutrient contents and non-burning increased SOM, TN, and TC contents in the top 10 cm. Large fertilizer levels contributed to changes in soil nutrient contents and increased soil pH. Overall, each agricultural management practice studied had both positive and negative effects on near-surface soil properties. Further research will help clarify and solidify the results of this study.

Acknowledgments

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Developing Cultural Competence Among 4-H Leaders

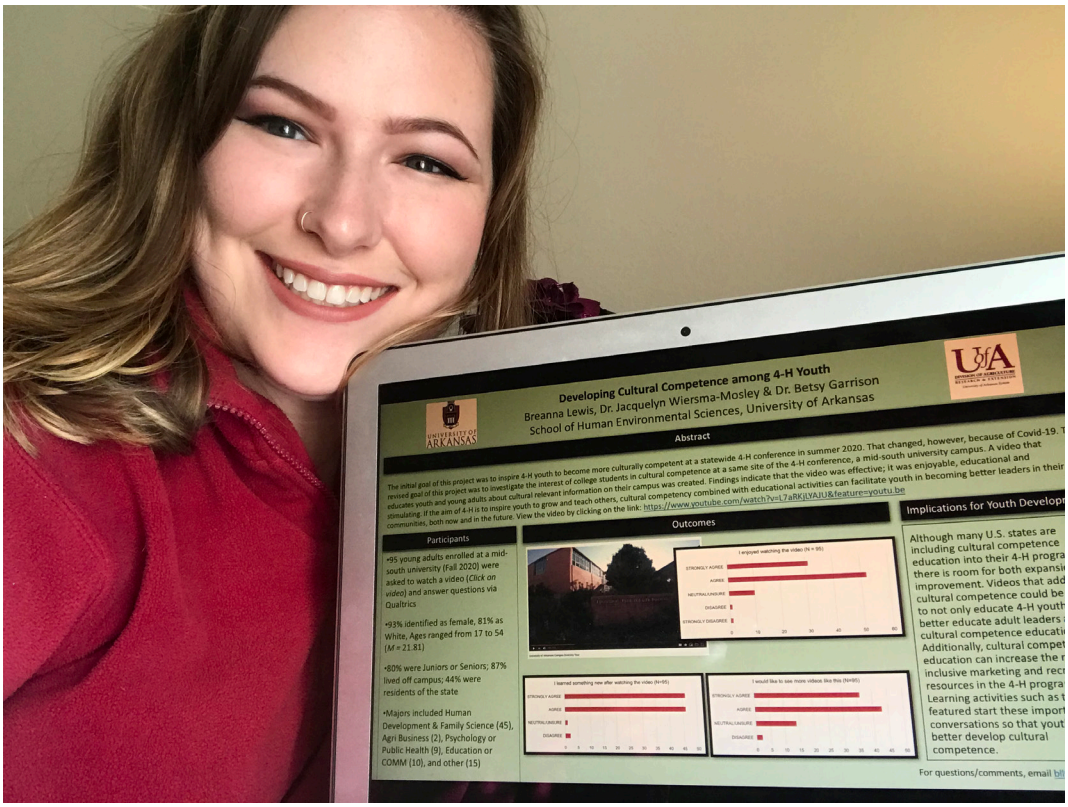
Meet the Student-Authors

Breanna Lewis Wade

I have always had an immense passion for 4-H. As a young child in Southern Arkansas, living on a farm, it was obvious that I should be involved. After 10 years of membership and current alumni participation, I can say that it has made me who I am today. As a first-generation student and transfer student from the University of Arkansas at Rich Mountain, I have had to fight hard for where I am today. I am glad to have had the resources and abilities that 4-H has equipped me with and hope to bestow the kind of passion I have towards other youth. As I have spent more time in academia, I have realized that it is my passion to find and gain resources for those who are underserved, as I have seen and understood the struggle that comes alongside certain disadvantages. During my time here, I have learned how to embrace my identity and have gained priceless insight on how to make that possible for others. I strive to bring cultural competence and opportunities specifically to youth development programs, with an emphasis on 4-H because I have seen the life-changing difference it can make for youth, and I want to make that a reality for many more going forward. Thank you to Dr. Jacquelyn Mosley for inspiring and supporting me every step of the way, to Dr. Betsy Garrison for making this opportunity a reality, and to my husband for loving and encouraging me in everything I do.

Devin Boggs Riley

I am a first-generation college graduate in the Human Environmental Science Program at the University of Arkansas, finishing my degree in Human Development and Family Science (HDFS). Thanks to the many incredible educators I have had along this journey, I realized I wanted to give back as they have given to me. One of the big topics I have studied and have grown close to during this last year as an undergraduate is Diversity, Equity, and Inclusion (DEI). My research mentor Dr. Jacquelyn Mosley has expanded my knowledge and helped me continue to develop my critical thinking skills to become a more culturally competent scholar. This has enhanced my skill set to work with all different cultures and backgrounds and help people on their DEI journey. Being a partner with Breanna Lewis Wade on her research in youth development regarding developing cultural competency among 4-H leaders has been an exceptional experience. I hope that the DEI efforts put in today will have a lasting effect on generations to come in our country.



Breanna presenting research at the 2020 National Association of Extension 4-H Youth Professionals Conference.

Research at a Glance

- This research focused on identifying the need for increased cultural competence education among 4-H leaders through independently sourced data within cultural competence training and literature review.

- With increased growth in the diverse 4-H youth population, there is also a growing need for better cultural competence education for students and their leaders to equitably provide and promote resources for all.

- This study found that although independent training and testing did not increase cultural competence overall, most 4-H leaders agreed there is a need and desire for making more cultural competence resources available and required.

Developing Cultural Competence Among 4-H Leaders

Breanna Lewis Wade,[*] *Devin Boggs Riley,*[†] *Jacquelyn D. Wiersma-Mosley,*[§] *and Betsy Garrison*[‡]

Abstract

Access, equity, diversity, and inclusion are essential elements of 4-H's goals related to positive youth development and organizational sustainability. The 4-H organization has impacted over 6 million youth worldwide and continues to grow every day. At the county, state, and national level, 4-H programs have grown more diverse, making it essential that 4-H programs encourage and highlight cultural similarities and differences through education. However, training in cultural competence for 4-H leaders is lacking, which is the bridge to connecting diversity and inclusion. Cultural competency is an awareness of one's own cultural identity and the ability to interact effectively and appropriately with people from other cultures. This project utilized a multidisciplinary and collaborative effort to deliver cultural competence training for 27 4-H young adult and adult leaders in a mid-South U.S. state. All participants completed pre-assessments of the Intercultural Development Inventory (IDI), participated in 2-hour training sessions on cultural competence, and completed post-IDI assessments three months later. Overall, most 4-H leaders scored in the Minimization orientation, which is the most common orientation among adults. In order to advance beyond the Minimization orientation to the Acceptance orientation, 4-H educators need additional educational opportunities, which may aid them in understanding crucial differences between cultures. The cultural competency model of the IDI provides a valuable framework in preparing culturally sensitive 4-H educators to construct settings where equity, access, and opportunity are available to all youth, allowing 4-H members to better reach their potential as capable, caring, and competent leaders of today and tomorrow.

[*] Breanna Lewis Wade is a May 2021 graduate with a major in Human Development and Family Sciences in the School of Human Environmental Sciences.

[†] Devin Boggs Riley is a May 2021 graduate with a major in Human Development and Family Sciences in the School of Human Environmental Sciences.

[§] Jacquelyn D. Wiersma-Mosley, a faculty mentor, is a Professor of Human Development and Family Sciences in the School of Human Environmental Sciences.

[‡] Betsy Garrison, a faculty mentor, is a Professor of Human Development and Family Sciences in the School of Human Environmental Sciences.

Introduction

Access, equity, diversity, and inclusion are essential elements of 4-H's goals related to positive youth development and organizational sustainability. The goal of this study was to assess and equip 4-H leaders with cultural competence education through the use of the Intercultural Development Inventory (IDI; Hammer, 2008). Cultural competence education can support healthier 4-H participation, better self-development, and leadership. 4-H is one of the nation's largest youth organizations, impacting over 6 million youth worldwide (ages 5 to 19), and also facilitates collegiate clubs across the country (4-H.org). The 4-H motto is "To make the best better," which is demonstrated through civic engagement, leadership, community service, and project specialties, among other outlets of opportunities.

While an increase in diverse members is celebrated, there also comes along with it a need for adequate education for 4-H professionals and leaders. 4-H strives to be an inclusive and accepting organization, and to do that requires adequate education. It is vital for cultural competence education to be available to 4-H leaders and professionals to create an inviting and accepting environment, not only for its members but for its leaders as well.

Cultural competence is an awareness of one's own cultural identity and the ability to interact effectively and appropriately with people from other cultures (Deardorff, 2011). The IDI (Hammer, 2008) was developed to measure individuals' lenses of cultural similarities and differences along a continuum from monocultural to intercultural worldviews. The IDI is an appropriate instrument for assessing 4-H educators because of the nature of the developmental process that can be supported through learning and experiences.

Cultural competence is necessary for increasing successful communication and understanding, especially among youth development professionals. One study indicated that 259 youth professionals and para-professionals reported that the importance of growing in cultural competence was not only for themselves but to better serve their youth-dominated audience (Williams and Mobley, 2007). Many 4-H leaders are encouraged to learn their area or state's demographics. For some 4-H youth, it is harder to find a connection with 4-H leaders and fellow 4-H members without an extensive understanding of the program. Many still assume that 4-H is strictly agricultural-based, which could have a hand in lower retention rates among diverse members because it does not include urban regions (Smith and Webster, 2018). Given the demographic changes that are occurring within the United States, many scholars argue that there is a systemic need to provide cultural competence education for organizations, especially those responsible for providing culturally competent services, such as youth leadership (Smith and Soule, 2016).

Another aspect of cultural competence and the ever-pressing push for available education is the existence of youth development professionals who are willing to address their biases. Woods (2004) stresses the importance of unbiased youth professionals (e.g., Future Farmers of America, FFA) alongside having the open-mindedness to adapt learning and teaching styles. Three major areas should be improved, including attitudes, policy, and practice. In a study with 127 youth development professionals, few professionals knew about policies or diversity resources, but many of them reported they were willing to learn how to address this lack of education if they were simply provided additional resources (Fox and LaChenaye, 2015).

The current study examined cultural competence among 4-H youth development leaders. The research questions were: (1) Where are 4-H educators, on average, in their cultural competence, using the IDI framework? and (2) Can cultural competence significantly increase among 4-H educators after attending cultural competence training?

Materials and Methods

Participants and Procedures

Data came from 27 4-H young adult and adult leaders in a mid-South U.S. state representing a collegiate 4-H club at a mid-South university and the State 4-H Office and 4-H Camp. The majority of the participants identified as women (67%) and White (80%) between the ages of 21 and 52. All participants volunteered to participate, and Institutional Review Board approval was obtained from the primary institution of data collection. Starting in December 2020, the Intercultural Development Inventory assessment was sent to each participant via email. One week later, all participants attended a virtual (Zoom) 1.5-hour training workshop led by both a licensed IDI Administrator and the Primary Investigator from the research team. During the presentation, cultural competence theories and definitions were reviewed, as well as research on implicit bias. Each participant was provided general information about cultural competence. The overall group results were discussed as well as what it meant to belong in each development orientation, according to the IDI. Steps that could be taken to increase cultural competence were suggested. Participants were asked to create SMART (Specific, Measurable, Attainable, Relevant, Time-based) goals regarding their own cultural competence. Finally, the post-IDI assessment was administered in March 2021, along with a Qualtrics survey asking demographic questions and closed- and open-ended questions about their experiences with the training and opinions regarding cultural competence education.

The IDI is a cross-cultural assessment of cultural competence used by companies, organizations, and schools all over the world. The assessment (costing $12/student; $18/non-student) consists of 50 multiple choice questions that extend from a monocultural mindset to a multicultural mindset in order to scale where an individual is in achieving cultural competence. Items include cultural experiences in terms of participants' (a) cross-cultural goals, (b) challenges that they confront while navigating cultural differences, (c) cultural incidents that they face when they encounter cultural differences, and (d) ways they address those cultural differences. The IDI ranges from a score of 50 to 145 that individuals are scored on for their Developmental Orientation (DO), which was used for this study. The DO indicates a participant's primary orientation toward cultural differences and commonalities along a continuum. The DO is the perspective that the person is most likely to use in situations where cultural differences and commonalities need to be bridged. Scores of 55 to 70 indicate Denial, 70 to 85 indicate Polarization, 85 to 115 indicate Minimization, 115 to 130 indicate Acceptance, and 130 to 145 indicate Adaptation.

The data were first analyzed as a group to measure the cultural competence of the 4-H leaders as a whole, examining the average Development Orientation (DO). Then, the pre- and post-assessments of the group DOs were compared to determine if there was a significant change within the three months of taking the assessment, using a paired *t*-test.

Results and Discussion

For the first research question, the participants' pre-IDI assessments were analyzed as a group, and the average pre-IDI DO was 95.41 (n = 27), indicating most 4-H leaders were in Minimization (refer to Fig. 1). The majority of participants (65.2%) were in Minimization, with 13% in Acceptance and 21.7% in Polarization. For the post-IDI assessment, the average DO was 97.46 (n = 16), which also represents Minimization (refer to Fig. 2). There were changes in the DO, indicating that only 36.4% were in Minimization three months later, whereas 27.3% were in Acceptance or Polarization. Unfortunately, only half (n = 16) of the original participants (n = 27) participated in the post-IDI. For the second research question, using a paired *t*-test, the group did not significantly increase in their DO, $t = 0.17$, $P = 0.87$.

As a follow-up to the training, we also assessed 4-H youth leaders on their overall views of the IDI training and regarding cultural competence education to seek further input regarding their SMART goal(s). Of those 4-H leaders (n = 16) who participated in the follow-up, 80% agreed cultural competence would enrich 4-H youth experiences, 73% agreed that the IDI should be offered to all 4-H professionals, and 73% agreed that additional training should be included in 4-H and Extension. Unfortunately, 12 (out of 13) educators who responded about their SMART goals indicated they were somewhat or not at all accomplishing their goal(s).

The majority of 4-H leaders fell within Minimization, which is highlighting commonalities too much that can mask a deeper understanding of cultural differences ("I don't see color," color-blindness). For those in the dominant culture (e.g., White/Caucasian), the emphasis is on maintaining comfort and focusing more on recruitment (i.e., diversity), but not retention (i.e., inclusion, sense of belonging). Individuals may often want to change and

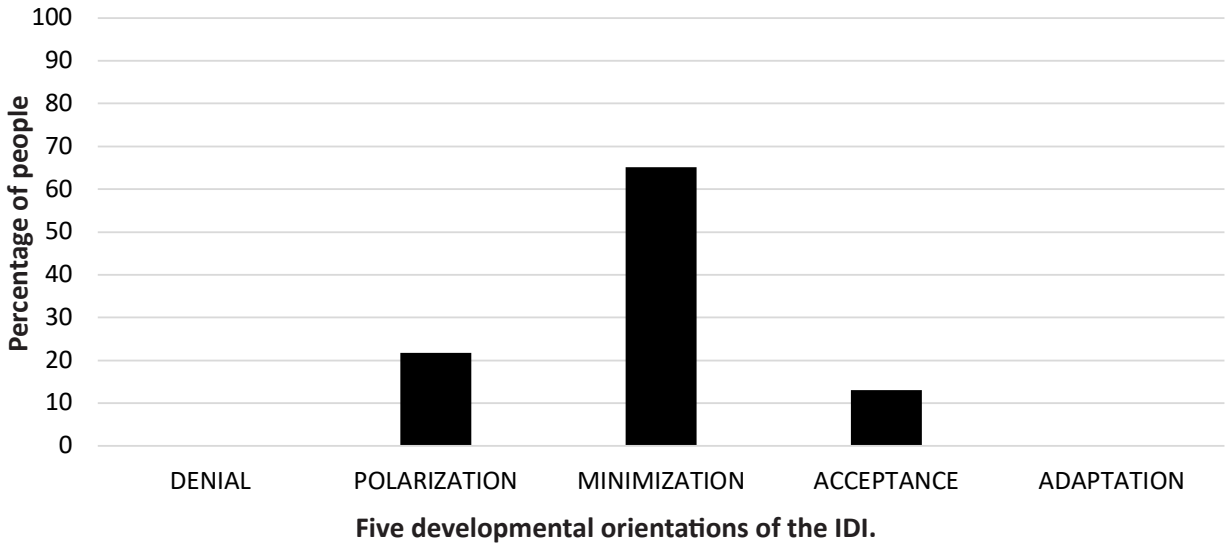


Fig. 1. Pre-Intercultural Development Inventory (IDI) Developmental Orientations (n = 27).

challenge others, but not themselves. For members of the non-dominant culture (e.g., BIPOC: Black, Indigenous, and People of Color), they may "go along to get along" for fear of being labeled negatively for speaking out. In general, individuals within Minimization value equality and want people from all racial/ethnic groups to be treated equally, but they may mask or minimize racial differences as a coping or survival mechanism (Harewood and Zemsky, 2020).

For cultural competence to develop among 4-H leaders, three major domains must be addressed: (1) identity development (i.e., self-awareness), (2) learning about cultural differences, and (3) bridging or adapting behavior with different groups. The best strategy for 4-H leaders to grow in cultural competence is to focus more on equity rather than equality. Equity recognizes systemic barriers and distributes resources based on the needs of individuals, while equality distributes the same resources to all individuals. The 4-H leaders within Minimization have really good intentions, but unfortunately, poor impact.

The present study's participants were primarily white women living in the mid-South. However, some research (Hu and Kuh, 2003; Loes et al., 2012; Pascarella et al., 2001) indicates that white individuals benefit more in critical thinking development when they are exposed to diversity educational training. A larger limitation to the study was both less participation in the post-IDI and the 3-month time frame, which is simply not enough time to foster cultural competence growth (Wiersma-Mosley, 2019).

As there is a need to educate 4-H youth professionals on cultural competence education, there is also increased interest from 4-H youth. New York 4-H youth members (aged 14 to 18) have strongly pushed for increased diversity and inclusion efforts within 4-H (Sumner et al., 2018). Many 4-H youth professionals have indicated that they would be receptive and open-minded to additional resources and educational training but simply did not have a clear place or direction to start (LaVergne, 2015). The current study expands on this research by providing 4-H professionals with one effective tool (e.g., IDI) that could support, sustain and strengthen their efforts in educating youth leadership. Moving forward, 4-H educators need additional resources, training, and support in implementing cultural competence growth.

Conclusions

Overall, a majority of 4-H educators participating in this study were in the Minimization orientation, which is the most common orientation among adults and comprises 65% of the population. In order to advance beyond the Minimization orientation, 4-H educators need educational opportunities that aid them in understanding concepts regarding equity, as well as other crucial differences between cultures. The cultural competency model of the IDI provides a valuable framework in preparing culturally sensitive 4-H educators to construct settings where equity, access, and opportunity are available to all youth, allowing 4-H members to better reach their potential as capable, caring, and competent leaders of today and tomorrow.

Acknowledgments

Funding for this project was provided by the Dale Bumpers College of Agricultural, Food, and Life Sciences Undergraduate Research Grant. This research was presented as a poster presentation for the Bumpers Honors College

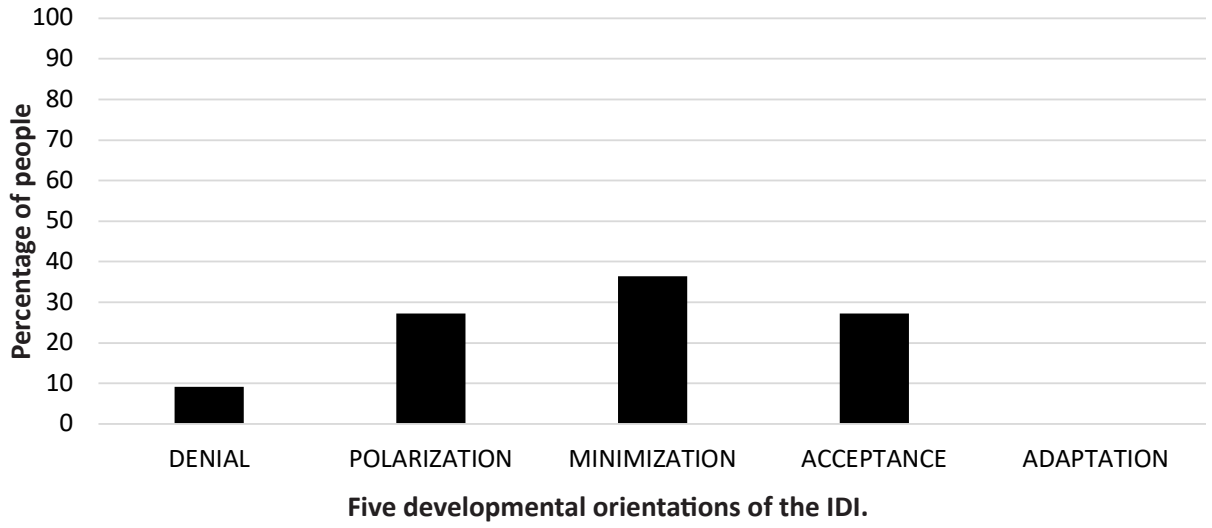


Fig. 2. Post-Intercultural Development Inventory (IDI) Developmental Orientations (n = 16).

Student Poster Competition, the National Undergraduate Research Week Poster Competition, and the 67th Annual NACTA Conference.

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Meet the Student-Author(s) and Research at a Glance:

The **Meet the Student-Author(s)** section consists of a professional headshot (taken by Fred Miller) of student author(s) as well as a short biography (240 words; 1400 characters with spaces) that tells readers about student author(s): (high school attended, activities and awards while at the university, etc.). Please see past issues for examples. This is the place to thank professors and advisors. For **Research at a Glance**, we will need 3 brief bullet points (100 character maximum, not including spaces) that clearly and succinctly explain the main takeaways of the research (i.e., overall what was done, significance and implications of findings) for a broad-based, non-technical audience. Please avoid using jargon and technical terms. We will need a photo of the student alongside these bullet points showing student-author(s) at work in the lab, field, traveling abroad, presenting a poster, receiving an award, etc. These photos will be loaded as supplemental files when submitting through the *Discovery* Journal location on ScholarWorks@UARK.

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The *Abstract* summarizes the purpose, procedures, and main findings in 250 words or less.

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The *Materials and Methods* section describes the experimental design, materials used, statistical analysis **(required)**, and any other details needed for another researcher to reproduce the study and to confirm the validity of findings and conclusions.

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The *Results and Discussion* section presents appropriate data, but not all data, in text, tables, and figures and places the findings in context with other research in the field. The discussion emphasizes new and important aspects of the research and conclusions that follow from them. Include the implications and impact of the findings. Relate your findings to observations of other studies. State new hypotheses when warranted, but avoid unqualified statements not supported by your data.

Conclusions

The *Conclusions* section presents a brief (one paragraph) summation of the research project presented in the paper and the significance of the findings and practical applications. No references are necessary and please do not introduce new material not discussed previously in the paper.

Acknowledgments

The *Acknowledgment* section recognizes financial support (undergraduate research grants, etc.) and other assistance. Note support by any companies or parties with a vested interest in the research results. Please thank your advisor, other professors, co-authors, and other individuals who helped with your research in the *Meet the Student-Author* section *NOT* in Acknowledgments.

Literature Cited

The *Literature Cited* section lists the complete references corresponding to those cited in the text. Within the text, references are indicated by (Last Name, Year); e.g., (Jones, 2000) (Smith and Jones, 2000) (Brown et al., 2000; Finn, 1998). List the complete citation alphabetically (by the first author's last name). Multiple citations of the same author are listed chronologically or by order of reference in the text if dated the same year.

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Submit your Word manuscript (with page numbers and continuous line numbering) as an 8.5 × 11-in. document, with double-spaced, 12-pt. text, in a single column, to the *Discovery* journal on ScholarWorks@UARK by choosing the Submit Article option on the left side of the screen at:

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- **Summer contact form** (see above for website link).
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- Publish with minor revision
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When a paper is accepted "with revisions," a revised manuscript will need to be submitted through ScholarWorks@UARK and the managing editor will approve a final draft for publication.

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Bumpers College provides life-changing opportunities to position and prepare graduates who will be leaders in the businesses associated with foods, family, the environment, agriculture, sustainability and human quality of life; and who will be first-choice candidates of employers looking for leaders, innovators, policy-makers and entrepreneurs. The college is named for Dale Bumpers, former Arkansas governor and longtime U.S. senator who made the state prominent in national and international agriculture.

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The University of Arkansas System Division of Agriculture's mission is to strengthen agriculture, communities, and families by connecting trusted research to the adoption of best practices. Through the Agricultural Experiment Station and the Cooperative Extension Service, the Division of Agriculture conducts research and extension work within the nation's historic land grant education system. The Division of Agriculture is one of 20 entities within the University of Arkansas System. It has offices in all 75 counties in Arkansas and faculty on five system campuses.

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