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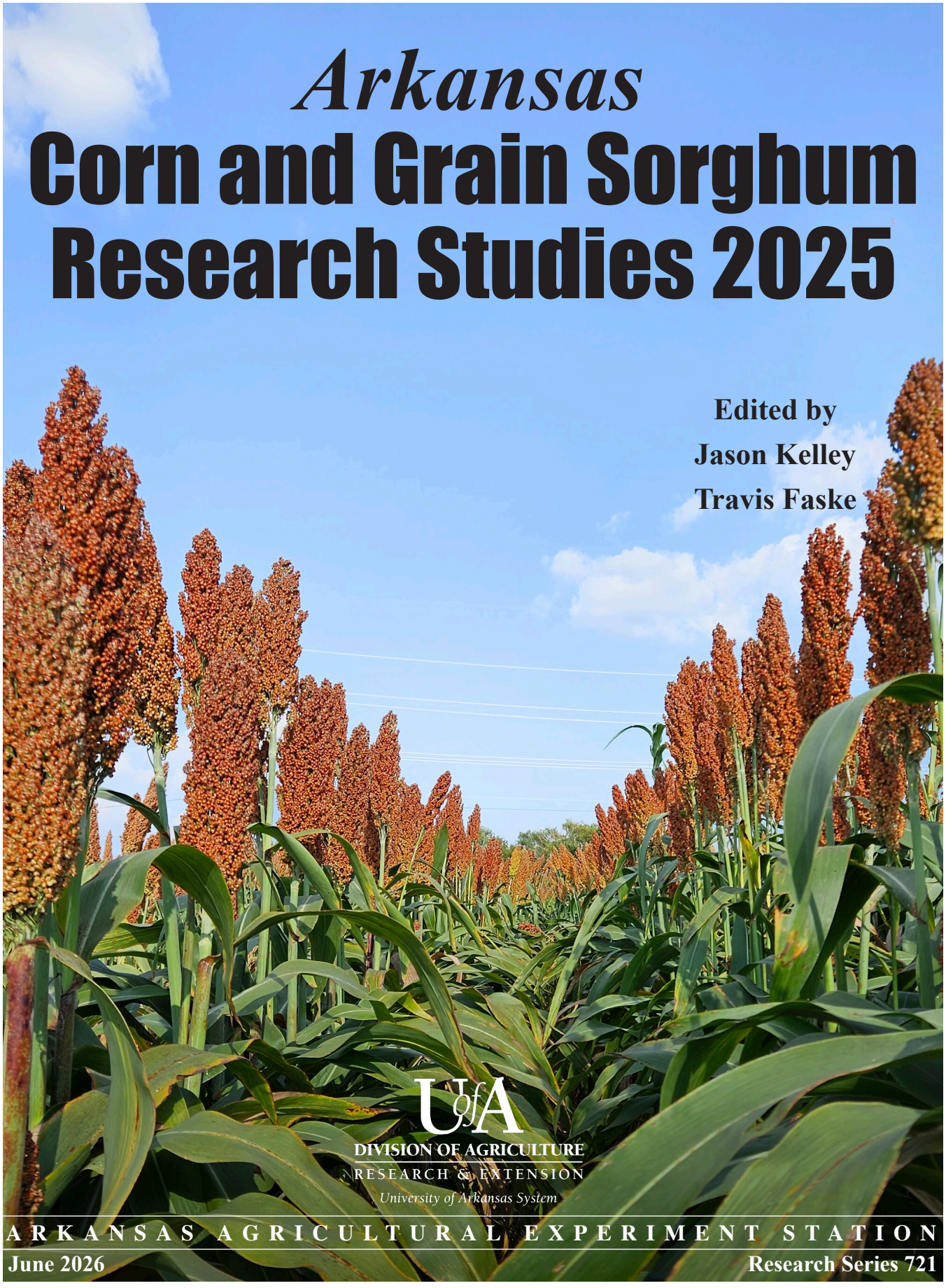
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Arkansas
Corn and Grain Sorghum Research Studies 2025



Edited by

Jason Kelley

Travis Faske

DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

ARKANSAS AGRICULTURAL EXPERIMENT STATION

June 2026 Research Series 721

This publication is available on the internet at: https://aaes.uada.edu/communications/publications/

The photo is a representative grain sorghum hybrid with the ArkTam™ herbicide-resistance trait, co-developed by the University of Arkansas Division of Agriculture and Texas A&M AgriLife Research. (Photo courtesy of Daniel Crozier/Texas A&M AgriLife Research).

Layout and editing by Gail Halleck.

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ISSN: 2692-1715 CODEN: AKAMA6

ARKANSAS
CORN AND GRAIN SORGHUM
RESEARCH STUDIES
– 2025 –

Jason Kelley and Travis Faske, Editors
University of Arkansas Division of Agriculture,
Little Rock and Lonoke, Arkansas

Arkansas Agricultural Experiment Station
University of Arkansas
Division of Agriculture
Fayetteville, Arkansas 72704

INTRODUCTION

The 2025 edition of the Arkansas Corn and Grain Sorghum Research Studies Series includes research results on topics pertaining to corn and grain sorghum production, including weed, disease, nematode, and insect management; economics; irrigation; agronomics; soil fertility; drone use; research verification program results; and numerous miscellaneous topics.

Our objective is to capture and broadly distribute the results of research projects funded by the Arkansas Corn and Grain Sorghum Board. The intended audience includes producers and their advisors, current investigators, and future researchers. The Series serves as a citable archive of research results.

The reports inform and guide our long-term recommendations, but should not be taken solely as our recommended practices. Some reports may appear in other University of Arkansas Division of Agriculture's Arkansas Agricultural Experiment Station publications. This duplication results from the overlap between disciplines and our effort to broadly inform Arkansas corn and grain sorghum producers of the research conducted with funds from the Corn and Grain Sorghum Check-off Program. This publication may also incorporate research partially funded by industry, federal, and state agencies.

The use of products and trade names in any of the research reports does not constitute a guarantee or warranty of the products named and does not signify that these products are endorsed or approved to the exclusion of comparable products. All authors are either current or former faculty, staff, or students of the University of Arkansas Division of Agriculture or scientists with the United States Department of Agriculture, Agricultural Research Service.

We extend thanks to the staff at the state and county extension offices and the research centers and stations, producers and cooperators, and industry personnel who assisted with the planning and execution of the programs.

Jason Kelley and Travis Faske, Editors
University of Arkansas Division of Agriculture,
Little Rock and Lonoke, Arkansas

ACKNOWLEDGMENTS

The research results in this publication were made possible through funding provided by the Corn and Grain Sorghum producers of Arkansas and administered by the Arkansas Corn and Grain Sorghum Promotion Board. We express sincere appreciation to the producers and the Arkansas Corn and Grain Sorghum Promotion Board members for their vital financial support of these programs.

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2025 Corn and Grain Sorghum Research Verification Program

C. Capps,[1] J.P. Kelley,[2] B. Deaton,[3] and C.R. Stark Jr.[3]

Abstract

During 2025, the Corn and Grain Sorghum Research Verification Program (CGSRVP) was conducted on ten irrigated corn fields. Counties participating included Arkansas, Cross, Drew, Jefferson, Lonoke, Mississippi, Monroe, Phillips, Poinsett, and Woodruff. Corn grain yield averaged 225 bu./ac across the ten fields. The Arkansas state average corn grain yield for 2025 was 182 bu./ac (USDA-NASS, 2026). Fields were planted between 19 March and 23 April, with an average planting date of 10 April. Final plant populations ranged from 30,900 to 33,800 plants/ac and averaged 32,637 plants/ac. Fields were furrow irrigated 3 to 4 times, depending on the field, and as indicated by soil moisture sensors. Preplant fertilizer applied averaged 43-53-75-7-3 lb/ac of nitrogen, phosphorus, potassium, sulfur, and zinc, respectively. The average total in-season fertilizer applied across all fields was 229-56-74-14-3 lb/ac of nitrogen, phosphorus, potassium, sulfur, and zinc, respectively. The resulting nitrogen fertilization program achieved 1.0 bu. of corn grain for every 1.02 lb/ac nitrogen fertilizer applied. Economic returns to total specified costs/acre were $249.78 when no land charges were applied. Fertilizer/nutrients and seed were the largest input costs at $214.03/ac and $134.98/ac, respectively, accounting for 31% and 20% of total operating expenses.

Introduction

The Arkansas Corn and Grain Sorghum Research Verification Program (CGSRVP) is a public demonstration of research-based Extension recommendations in farmers' fields. The programs emphasize intensive management with timely inputs and integrated pest management to maximize yields and net returns. The overall goal is to verify that crop management using the University of Arkansas Division of Agriculture (UADA) recommendations can produce high-yielding, profitable corn and grain sorghum with current technology. The objectives of the programs are: 1) to educate producers on the benefits of using UADA recommendations to improve yields and/or net returns; 2) to conduct on-farm field trials to verify research-based recommendations; 3) to aid researchers in identifying areas of production that require further study; 4) to improve or refine existing recommendations that contribute to more profitable production; 5) to incorporate data into Extension educational programs at the county and state level; and 6) to provide in-field training to county agents, consultants, and producers on current production recommendations.

The CGSRVP began in 2000 with the initiation of a statewide check-off program for corn and grain sorghum, which the Arkansas Corn and Grain Sorghum Promotion Board administers. Since its inception, 205 corn or grain sorghum fields have been enrolled in the program across 36 counties.

Procedures

In the fall of each year, the CGSRVP program coordinator sends requests to county extension agents for enrollment in the program. County extension agents identify producers who want to be part of the program and agree to pay production expenses, provide crop expense information for economic analysis, and implement recommended production practices in a timely manner throughout the growing season. During the winter months, the program coordinator and county extension agent meet with the producer to discuss field expectations, review soil fertility, weed control, irrigation, insect control, and hybrid recommendations, and provide program details. As the planting season begins, the program coordinator, the county agent, and the cooperator scout each field weekly and discuss the management decisions needed for that week and the upcoming week. The program coordinator provides the county extension agent and producer with an electronic crop scouting report that outlines recommendations for the week and future expectations.

An on-site weather station provides in-field rainfall and high- and low-temperature data, which are used to calculate accumulated growing degree days. When applicable, irrigation well flow meters are installed before irrigation initiation to document the amount of irrigation water used during the year. Soil moisture sensors are installed in representative areas of the field early in the growing season to provide soil moisture information. They are used to determine the initiation, frequency, and termination of irrigation.

Results and Discussions

Overall corn yields during the 2025 growing season in the verification program ranged from 155 bu./ac in Mississippi County to 255 bu./ac in Arkansas County (Table 1). The overall average yield of the ten fields in the program was 225 bu./ac. The state average corn yield for 2025 was 182 bu./ac (USDA-NASS, 2025). All fields in the verification program were planted timely

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within the recommended planting date range. The average planting date for all fields was 10 April, with an average harvest date of 7 September. Plant populations averaged 32,637 plants/ac, a recommended level for most irrigated fields. Weather conditions were generally conducive for high corn yields across the state, as evidenced by a state average yield of 182 bu./ac. A wet early April delayed early planting in some areas, but good stands followed timely rainfall and moderate temperatures, helping produce high grain yields across the state.

The fertilizer applied to program fields closely followed current UADA recommendations and was based on soil analysis and yield goals (Table 2). Preplant fertilizer applied to fields averaged 43-53-75-7-3 lb/ac of nitrogen-phosphorus-potassium-sulfur-zinc, with nitrogen applied pre-plant or at planting accounting for approximately 19% of the total nitrogen applied during the season. Side-dressed nitrogen applied at the V4–V8 growth stage averaged 145 lb/ac with urea, ammonium sulfate, urea-ammonium nitrate, or a combination of those sources. A pre-tassel application of 100 lb of urea fertilizer/ac was aerially applied between the V12 and R1 growth stages (except in Monroe County), a common and recommended nitrogen application practice in Arkansas. Total nitrogen applied to fields averaged 229 lb/ac. Applied nitrogen fertilizer resulted in an average yield of 225 bu./ac, yielding 1 bushel of corn grain per 1.02 lb. of nitrogen fertilizer applied.

Pest management practices followed the current UADA recommendations. None of the corn fields met the thresholds requiring an insecticide application during the season, and three fields were sprayed with foliar fungicide for foliar diseases. Early planting is typically beneficial for disease management, particularly for southern corn rust (*Puccinia polysora*), and fields were planted early in 2025, thereby reducing the overall impact of foliar diseases. Herbicides applied to fields for weed control varied by field, but the most used herbicide combinations were metolachlor, atrazine, and mesotrione, applied in a one- or two-pass program.

Irrigation is a critical management practice for Arkansas corn. Approximately 92.5% of the corn acres grown for grain were irrigated (USDA-FSA 2025). Irrigation initiation, frequency, and termination were scheduled using the Arkansas Irrigation Scheduler program and soil moisture sensors to monitor soil moisture content. In 2025, overall irrigation requirements for corn were about average across most fields compared to previous years, and each field was irrigated an average of 3.6 times (Table 3). Each furrow irrigation was estimated to provide two acre-inches of irrigation water. Average rainfall on corn fields in 2025 from planting to maturity was 18.19 inches, demonstrating that total rainfall may be adequate for corn production, but the poor distribution of rainfall during the growing season is the reason such a high percentage of Arkansas corn is irrigated.

On-site weather stations provided high and low-temperature data to allow for accurate measurement of Growing Degree Days (GDD). The formula used to determine GDDs for corn is as follows:

$$\text{GDDs} = \frac{(\text{Daily Maximum Air Temperature} + \text{Daily Minimum Temperature})}{2} - 50$$

with a maximum air temperature of 86 °F and a minimum temperature for growth of 50 °F. During weekly field visits, corn growth stages were recorded and compared to accumulated GDDs. Table 4 shows the 2025 average GDDs accumulated by each growth stage listed. These values align closely with reported GDDs needed to reach maturity for full-season hybrids (112–120 days) that we typically grow in Arkansas. GDDs can accurately predict corn growth stages and support management decisions, such as irrigation termination.

Economic Analysis

Records of field operations for each field were compiled by the CGSRVP coordinator, the county extension agent, and the producer and serve as the basis for estimating costs and economic returns, which are discussed in this section. Production data from the ten irrigated corn fields were applied to determine costs and returns above operating costs and total specified costs. Operating costs and total costs/bu. indicate the commodity price needed to meet each cost type.

Production expenses are expenditures that require annual cash outlays and are included in an operating loan application. Actual quantities of all production inputs reported by the cooperators are used in this analysis. Input prices are determined by data from the 2025 Crop Enterprise Budgets (Watkins, 2025), published by the Cooperative Extension Service, and information provided by the producer cooperators. Fuel and repair costs for machinery are calculated using a budget calculator based on parameters and standards established by the American Society of Agricultural and Biological Engineers. Machinery repair costs should be treated as estimates for full-service repairs. The actual cash outlays could differ as producers utilize employee labor or provide unpaid labor for equipment maintenance.

Operating expenses include production expenses, interest paid on operating capital, and all post-harvest expenses. As applicable for each crop, post-harvest expenses include hauling, drying, check-off fees, and other costs typically incurred after harvest. Post-harvest expenses increase or decrease with yield.

Ownership costs of machinery are determined by a capital recovery method, which determines the amount of money that should be set aside each year to replace the value of equipment used in production. Machinery costs are estimated by applying engineering formulas to represent new equipment prices. This measure differs from typical depreciation methods and actual annual cash expenses for machinery but establishes a benchmark that estimates farm profitability.

Operating costs, total costs, costs/bu., and returns are presented in Tables 5 and 6. This report does not include land costs, management, or other expenses and fees not associated with production. The corn grain price used for economic calculations was $4.54/bu. and was calculated from Arkansas Daily Grain reports published by the Agricultural Marketing Service, U.S. Department of Agriculture. The price is a simple average of Arkansas 2025 crop booking and cash prices from 1 January through 31 August 2025. The average yield from verification fields was 225 bu./ac.

The production expenses were $682.13/ac in 2025 (Table 6). On average, fertilizers and nutrients were the largest expense

category at $214.03/ac or 31% of production expenses. Seed costs averaged $134.98/ac, which was 20% of production expenses.

With an average corn yield of 225 bu./ac across all fields, operating costs were $682.13/ac in 2025. The return to operating costs for all fields in 2025 was $341.19/ac, and average fixed costs for fields were $91.41/ac. The return to total cost for fields was $249.78/ac, and total specified costs for all fields in 2025 averaged $3.49/bu. (Table 5).

Practical Applications

The corn and grain sorghum research verification program continues to serve as a field-scale demonstration of all UADA recommendations for growing corn and grain sorghum in Arkansas. It serves as a method for evaluating recommendations and for adjusting or defining areas that may require further research in the future. The program results are compiled into a database to enable long-term monitoring of agronomic and economic trends in Arkansas corn and grain sorghum production. The program also aids in educating new county agents, consultants, and producers who are less familiar with current production recommendations.

Areas of new or ongoing research being evaluated in the corn and grain sorghum program fields include foliar tissue testing during the season to assess whether current fertilizer recommendations for corn provide adequate levels of nutrients in the plants. Tissue samples will be taken during the V10-tassel stage to determine whether nitrogen levels in the plant were adequate and if a pre-tassel nitrogen application was needed. End-of-season corn stalk nitrate samples will also be collected to determine if nitrogen was sufficient during the season and to evaluate overall nitrogen efficiency. Soil moisture sensors were used in all corn fields to track soil moisture levels, and will help serve as a testing program for using soil moisture sensors for irrigation timing. The verification fields serve as a pest-monitoring program for foliar corn diseases, such as southern rust, to alert farmers to potential pest problems.

The corn research verification has annually demonstrated that corn can be profitable for Arkansas farmers. The published research-based recommendations for corn production are dependable for profitable, high-yielding, and sustainable production. The UADA Extension recommendations will be revised according to new findings and used in the verification program to ensure continued success for Arkansas corn farmers.

Acknowledgments

The authors appreciate the support provided by Arkansas corn and grain sorghum producers through check-off funds administered by the Arkansas Corn and Grain Sorghum Promotion Board. In addition, we appreciate the cooperation of participating producers and County Extension agents who enrolled in the program. Support was also provided by the University of Arkansas Division of Agriculture.

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Table 1. 2025 Corn Research Verification Program locations, hybrid planted, hybrid maturity, field size, row spacing, previous crop, plants per acre, plant date, harvest date, and yield.

County	Hybrid	Hybrid Maturity	Field Size	Row Space	Previous Crop	Plants Per Acre	Plant Date	Harvest Date	Yield
		(days)	(ac)	(in.)					(bu./ac)
Arkansas	DeKalb DKC 68-35	118	212	38	soybean	33,200	4/11	9/7	255
Cross	DeKalb DKC 68-35	118	38	30	soybean	30,900	4/13	8/18	237
Drew	Dyna-Gro D57TC29	117	38	38	soybean	32,900	3/25	8/6	259
Jefferson	DeKalb DKC 65-99	115	70	30	soybean	32,428	4/16	8/19	220
Lonoke	DeKalb DKC 65-92 Conv	115	46	38	soybean	33,667	4/23	9/29	213
Mississippi	Becks 6973TCV2N	119	75	38	soybean	32,800	4/18	10/2	155*
Monroe	Dyna-Gro 58VC74	118	38	30	soybean	33,800	4/15	8/27	228
Phillips	DeKalb DKC 68-35	118	46	38	soybean	31,875	4/11	8/20	235
Poinsett	DeKalb DKC 70-25	120	34	38	soybean	32,000	4/15	9/30	225
Woodruff	Croplan 5370VT2P	113	42	30	soybean	32,800	3/19	8/6	227
Mean	---	**117**	**64**	**---**	**---**	**32,637**	**4/10**	**9/7**	**225**

* Field was precision leveled in the spring of 2025 with deep cuts in several areas, resulting in a lower yield.

Table 2. 2025 Corn Research Verification Program locations, preplant, sidedress, pretassel, total fertilizer applied, and soil type.

County	Preplant Fertilizer	Sidedress	Pretassel[a]	Total Fertilizer	Soil Type
	----------Applied Fertilizer lb/ac of N-P-K-S-Zn----------				
Arkansas	38-68-82-12-5	138-0-0-12-0	46-0-0-0-0	222-69-82-12-5	DeWitt Silt Loam
Cross	34-0-60-12-0	161-0-0-0-0	46-0-0-0-0	241-0-60-12-0	Crowley Silt Loam
Drew	44-35-70-0-5	124-23-0-12-0	46-0-0-0-0	211-58-70-12-5	Hebert Silt Loam
Jefferson	38-69-90-12-0	132-0-0-12-0	46-0-0-0-0	216-69-90-12-0	Coushatta Silt Loam
Lonoke	46-54-90-0-10	126-0-0-12-0	46-0-0-0-0	218-54-90-12-10	Immanuel Silt Loam
Mississippi	46-45-60-0-0	184-0-0-0-0	46-0-0-0-0	276-45-60-0-0	Sharkey Silty Clay
Monroe	70-80-90-10-10	161-0-0-0-0	0-0-0-0-0	231-80-90-10-10	Grenada Silt Loam
Phillips	35-60-80-0-0	159-0-0-24-0	46-0-0-0-0	240-60-80-24-0	Convent Silt Loam
Poinsett	45-59-60-12-0	126-0-0-12-0	46-0-0-0-0	217-59-60-24-0	Mhoon Silt Loam
Woodruff	34-62-62-10-2	140-0-0-12-0	46-0-0-0-0	220-62-62-22-2	Teksob Silt Loam
Mean	**43-53-75-7-3**	**145-2-0-10-0**	**41-0-0-0-0**	**229-56-74-14-3**	**---**

[a] Applied between V12 to R1 (silking) corn growth stages.

Table 3. 2025 Corn Research Verification Program locations, irrigation type, number of irrigations, and rainfall from planting to maturity.

County	Irrigation Type	Irrigation Frequency[a]	Rainfall from planting to maturity
		(Irrigations/season)	(in.)
Arkansas	Furrow	3	15.53
Cross	Furrow	4	15.71
Drew	Furrow	4	17.38
Jefferson	Furrow	4	11.70
Lonoke	Furrow	3	13.67
Mississippi	Furrow	4	21.90
Monroe	Furrow	4	17.51
Phillips	Furrow	3	14.61
Poinsett	Furrow	4	23.34
Woodruff	Furrow	3	30.54
Mean	**---**	**3.6**	**18.19**

[a] Each furrow irrigation supplied approximately 2 ac-in. of irrigation water.

Table 4. The corn growth stage and the corresponding average accumulated growing degree days were determined by weekly field visits in all corn fields in 2025.

Corn Growth Stage	Accumulated Growing Degree Days From Planting
VE – Emergence	155
V2	272
V4	437
V6	615
V8	788
V10	937
V12	1077
V14	1186
V16	1298
R1 – Silking	1475
R2 – Blister	1634
R3 – Milk	1820
R4 – Dough	2011
R5 – Dent	2190
R6 – Physiological Maturity (Black Layer)	2852

Table 5. Operating costs, total costs, and returns for corn research verification program fields, 2025.

County	Operating Costs	Operating Costs	Returns to Operating	Fixed Costs	Total Costs	Returns to Total Costs	Total Costs per Bushel
	($/ac)	($/bu.)	----------($/ac)----------				($/bu.)
Arkansas	727.18	2.85	430.52	97.11	824.29	333.41	3.23
Cross	632.21	2.67	443.77	99.03	731.25	344.73	3.09
Drew	672.76	2.60	503.10	97.05	769.81	406.05	2.97
Jefferson	684.07	3.11	314.73	98.18	782.25	216.55	3.56
Lonoke	670.43	3.15	296.59	81.58	752.02	215.00	3.53
Mississippi	684.23	4.41	19.47	86.96	771.81	-67.48	4.98
Monroe	717.96	3.15	317.16	84.61	802.57	232.55	3.52
Phillips	684.73	2.91	382.17	82.89	767.62	299.28	3.27
Poinsett	674.08	3.00	347.42	88.95	763.03	258.47	3.39
Woodruff	673.63	3.08	356.95	97.71	771.34	259.24	3.40
Mean	**682.13**	**3.08**	**341.19**	**91.41**	**773.54**	**249.78**	**3.49**

Table 6. Summary of operating costs, total costs, and returns for corn research verification program fields, 2025.

	Arkansas	Cross	Drew	Jefferson	Lonoke
Yield (bu./ac)	255.00	237.00	259.00	220.00	213.00
Price ($/bu.)	4.54	4.54	4.54	4.54	4.54
Total Crop Revenue	1157.70	1075.98	1175.86	998.80	967.02
Production Expenses	----------$/ac----------				
Seed	139.11	138.27	142.96	139.95	111.18
Fertilizers and Nutrients	233.47	168.00	198.95	213.42	235.45
Herbicides	32.72	15.33	28.39	28.36	36.50
Fungicide	7.50	7.50	0.00	7.50	0.00
Custom Application	40.80	40.80	27.20	27.20	44.20
Diesel Fuel, Field Activities	17.28	15.40	17.02	14.33	15.45
Irrigation Energy Costs	10.54	14.05	14.05	26.46	10.54
Other Inputs, Pre-harvest	16.25	16.25	16.25	16.25	16.25
Input Costs					
Consultant Fees	6.00	6.00	6.00	6.00	6.00
Crop Insurance	34.00	34.00	34.00	34.00	34.00
Repairs and Maintenance	23.16	22.39	21.46	22.10	17.96
Labor, Field Activities	9.23	10.16	10.37	10.37	8.79

Continued

Table 6. Continued.

	Mississippi	Monroe	Phillips	Poinsett	Woodruff	Mean
Yield (bu./ac)	155.00	228.00	235.00	225.00	227.00	225.00
Price ($/bu.)	4.54	4.54	4.54	4.54	4.54	4.54
Total Crop Revenue	703.70	1035.12	1066.90	1021.50	1030.58	1023.32
Production Expenses	----------$/ac----------					
Seed	142.46	142.46	139.95	113.60	140.37	134.98
Fertilizers and Nutrients	216.00	272.04	190.50	207.00	205.47	214.03
Herbicides	39.70	32.72	42.29	45.97	34.91	33.69
Fungicide	0.00	0.00	0.00	0.00	0.00	0.00
Custom Application	68.00	17.00	52.70	44.20	35.70	39.78
Diesel Fuel, Field Activities	13.64	13.37	12.89	13.13	18.02	15.05
Irrigation Energy Costs	14.05	14.05	19.84	26.46	10.54	16.06
Other Inputs, Pre-harvest	16.25	16.25	16.25	16.25	16.25	16.25
Input Costs						
Consultant Fees	6.00	6.00	6.00	6.00	6.00	6.00
Crop Insurance	34.00	34.00	34.00	34.00	34.00	34.00
Repairs and Maintenance	19.06	18.62	19.47	19.47	22.69	20.51
Labor, Field Activities	8.57	7.89	6.67	7.89	8.62	8.86

Continued

Table 6. Continued.

	Arkansas	Cross	Drew	Jefferson	Lonoke
Expenses	----------$/ac----------				
Interest	27.08	23.19	24.52	25.93	25.48
Post-harvest Expenses	130.05	120.87	132.09	112.20	108.63
Total Operating Expenses	727.18	632.21	672.76	684.07	670.43
Returns to Operating Expenses	430.52	443.77	503.10	314.73	296.59
Capital Recovery and Fixed Costs	97.11	99.03	97.05	98.18	81.58
Total Specified Expenses	824.29	731.25	769.81	782.25	752.02
Returns to Specified Expenses	333.41	344.73	406.05	216.55	215.00
Operating Expenses Per bu.	2.85	2.67	2.60	3.11	3.15
Total Specified Expenses Per bu.	3.23	3.09	2.97	3.56	3.53

Continued

Table 6. Continued.

	Mississippi	Monroe	Phillips	Poinsett	Woodruff	Mean
Expenses						
Interest	27.44	27.28	25.62	25.26	25.30	25.72
Post-harvest Expenses	79.05	116.28	119.85	114.75	115.77	114.95
Total Operating Expenses	684.23	717.96	684.73	674.08	673.63	682.13
Returns to Operating Expenses	19.47	317.16	382.17	347.42	356.95	341.19
Capital Recovery and Fixed Costs	86.96	84.61	82.69	88.95	97.71	91.41
Total Specified Expenses	771.18	802.57	767.62	763.03	771.34	773.54
Returns to Specified Expenses	-67.48	232.55	299.28	258.47	259.24	249.78
Operating Expenses Per bu.	4.41	3.15	2.91	3.00	2.97	3.08
Total Specified Expenses Per bu.	4.98	3.52	3.27	3.39	3.40	3.49

Economic Analysis of the 2025 Arkansas Corn and Grain Sorghum Research Verification Program

B.D. Deaton[1] and C.R. Stark, Jr.[1]

Abstract

The economic results of a statewide corn and grain sorghum research verification program can be a useful tool for producers making production management decisions prior to and within a crop-growing season. The 2025 season results provide additional economic insights between conventional (no traits) and stacked trait corn (herbicide + *Bt*) systems. All fields were furrow irrigated this year. This is in contrast to past years, when there was at least one center-pivot irrigated field. The stacked trait fields had an average yield that was 13.78 bu./ac higher than that of the conventional field. The stacked trait fields also had an average $38.64/ac higher return to land and management than the conventional field.

Introduction

The Arkansas Corn and Grain Sorghum Research Verification Program (CGSRVP) originated in 2000, and records have been compiled each succeeding year from the fields of participating cooperators until 205 individual fields now comprise the state data set. Among other goals, the program seeks to validate the University of Arkansas Division of Agriculture's Cooperative Extension Service (CES) standard corn and grain sorghum production recommendations and demonstrate their benefits to state producers. Cooperating producers in each yearly cohort are identified by their county extension agent for agriculture. Each producer receives timely management guidance from state CGSRVP coordinators on a regular basis and from state extension specialists as needed. CGSRVP coordinators record input rates and production practices throughout the growing season, including official yield measures at harvest. A CES state extension economist compiles the data into the spreadsheet used for annual cost of production budget development. Measures of profitability and production efficiency are calculated for each cooperator's field and then grouped by production system.

Procedures

Ten cooperating corn producers from across Arkansas provided input quantities and production practices utilized in the 2025 growing season. A state average corn market price was estimated by compiling daily forward booking and cash market prices for the 2025 crop. The price collection period was 1 January through 31 August 2025. These prices are the same as those used for the weekly corn and grain sorghum market reports published on the Arkansas Row Crops Blog (Deaton, 2026). Data was entered into the 2025 Arkansas corn and grain sorghum enterprise budgets for each respective production system (Watkins, 2025). Input prices and production practice charges were primarily estimated by values given in the enterprise budgets. Missing values were estimated using a combination of both industry representative quotes and values taken from the Mississippi State Budget Generator program for 2025 (Laughlin and Spurlock, 2016). Summary reports, by field, were compiled to generate system results.

Results and Discussion

The 10 fields included in the 2025 Arkansas Corn and Grain Sorghum Research Verification Program report (Capps et al., 2025) had an average yield of 225.40 bu./ac, generating an average revenue of $1023.32/ac. Producers required $682.13/ac of variable costs and $91.41/ac of fixed costs, or a total cost per acre of $773.54, resulting in an average return to land and management of $249.78/ac. Nine fields used stacked herbicide (herbicide + *Bt*) technology, and 1 field used conventional herbicide technology. All fields used furrow irrigation. All economic comparisons were developed from corn daily forward booking and cash market prices for the 2025 crop reported by Deaton in weekly market reports (Deaton, 2026). The corn forward booking and cash market price for the 2025 crop averaged $4.54 per bushel over the period of 1 Jan.–31 Aug. 2025. This price is 22 cents higher than the 2024 market price of $4.32. Market price multiplied by yield gave field revenues. No grade reductions or premiums were included in the economic analysis. All yields were standardized to 15.5% moisture content. Readers should note that the small number of fields in total and the numbers within groups of fields represented in this study do not permit standard statistical analysis. Yield and economic results are presented by grouping for discussion purposes only. Economic comparisons are drawn strictly across corn traits (Table 1) this year because there were no differences in irrigation. The values for yield, revenue, total variable cost, total fixed cost, total cost, and return to land and management are discussed by characteristics. Variable costs include such items as fuel, seed, fertilizer, chemicals, and hired labor. Fixed costs include estimates of capital recovery values for all field equipment and irrigation systems used. No land rent was charged. Returns may be regarded as the return to management and operator labor.

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Trait Comparisons

The stacked trait (herbicide + *Bt*) system was used in 9 fields, while the conventional (no herbicide or insect trait) system was used in 1 field (Table 1). Yield comparisons by system show that the stacked trait (herbicide + *Bt*) fields had an average 13.78 bu./ac. advantage over the conventional field. The stacked trait fields also had an average $62.55/ac higher revenue, $13.00/ac higher variable costs, $10.92/ac higher fixed costs, $23.91/ac higher total costs, and $38.64/ac higher return to land and management than the conventional field.

Overall Comparisons

The 2025 Arkansas Corn and Grain Sorghum Research Verification Program fields had a 225.40 bu./ac statewide average yield. This was 12.15 bushels more than in 2024 and 43.40 bushels above the 2025 Arkansas state average yield of 182 bu./ac (USDA, 2025). Revenue averaged $1023.32 from this production and market price of $4.54. The revenue represents an increase of $103.14/ac compared to 2024, primarily due to higher yields in 2025. Variable costs averaged $682.13, a $28.82 increase, and fixed costs averaged $91.41, a $30.37 decrease, for an average total cost per acre of $773.54, a $1.55 decrease compared to 2024. These revenue and cost averages left producers with an average per-acre return to land and management of $249.78 across all production systems, a $104.69 increase per acre compared to 2024.

Practical Applications

The results of state research verification programs can provide valuable information to producers statewide. An illustration of the returns generated when optimum management practices are applied can facilitate the distribution of new techniques and validate the standard recommendations held by state row crop production specialists. Adoption of these practices can benefit both producers currently growing corn and those contemplating production.

Acknowledgments

The authors wish to thank the Arkansas Corn and Grain Sorghum Board for the support provided by Arkansas corn producers through check-off funds administered by the board. Appreciation is given to the University of Arkansas Division of Agriculture and to the University of Arkansas at Monticello College of Forestry, Agriculture, & Natural Resources, both of which provided funding and other support for this research project. Appreciation is especially extended to Chuck Capps, Arkansas Corn and Grain Sorghum Research Verification Program Coordinator, and Jason Kelley, Arkansas Corn and Grain Sorghum Research Verification Program Director, without whom this research would not have been possible.

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Table 1. Economic results by trait system for the 2025 Corn and Grain Sorghum Research Verification Program.

Trait System	Conventional	Stacked	All Fields
# Fields	**1**	**9**	**10**
Yield (bu./ac)	213.00	226.78	225.40
Revenue ($/ac)	967.02	1029.57	1023.32
Variable Costs ($/ac)	670.43	683.43	682.13
Fixed Costs ($/ac)	81.58	92.50	91.41
Total Costs ($/ac)	752.02	775.93	773.54
Returns to Land and Management ($/ac)	**215.00**	**253.64**	**249.78**

Source: 2025 Arkansas Corn and Grain Sorghum Research Verification Program Report.

Evaluation of Corn Hybrids for Disease Resistance, 2025

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Abstract

Three corn hybrid trials were planted at the University of Arkansas Division of Agriculture's Rohwer Research Station in Kelso, the Lon Mann Cotton Research Station near Marianna, and the Rice Research and Extension Center near Stuttgart, in mid-May and early June to increase the likelihood of foliar disease development. Each trial had 47 hybrids that were rated for foliar diseases that commonly occur in Arkansas (such as southern corn leaf blight, northern corn leaf blight, gray leaf spot, southern rust, and Curvularia leaf spot). Foliar disease levels were low to moderate, depending on disease and location, and sometimes were significantly different among corn hybrids. Southern rust severity was significantly different among hybrids and had the greatest impact on yield at Rohwer. There was a relationship between increased levels of gray leaf spot and lower yields at Marianna; however, disease was variable and similar among hybrids. These data indicate that disease severity differs among hybrids and provide a list of options to select a high-yielding disease-tolerant hybrid.

Introduction

Each year, the Arkansas Crop Variety Improvement Program (Carlin et al., 2026) plants corn hybrid trials at five research station locations around the state to better understand corn hybrid performance in Arkansas growing conditions. Typically, data collected for each hybrid are yield (bu./ac), grain moisture, plant population/ac, plant lodging, ear height, and tip cover. In 2025, the Arkansas Corn and Grain Sorghum Promotion Board funded a project that allowed the same hybrids to be screened for susceptibility to diseases in late-planted trials at three locations. These data will help growers select high-yielding, disease-tolerant hybrids, potentially saving input costs of foliar fungicide applications during the growing season. The objectives of this work were to evaluate the corn hybrids entered in the Arkansas Crop Variety Improvement Program for susceptibility to common corn diseases in Arkansas and extend those results to farmers.

Procedures

Trials were planted at three University of Arkansas Division of Agriculture (UADA) locations: the Rohwer Research Station near Kelso, the Lon Mann Cotton Research Station near Marianna, and the Rice Research and Extension Center near Stuttgart, on 16 May, 23 May, and 2 June, respectively. These trials were planted about a month later than the standard hybrid trials at these locations in order to promote the likelihood of greater disease pressure. All trials were planted on raised beds in a single row, on 38-in. row spacing at Marianna and Kelso and 30-in. row spacing at Stuttgart, and furrow irrigated. Pest control and fertility were done following UADA recommendations. The plots were 20 feet long, two rows wide, and all 47 hybrids were arranged in a randomized complete block design with four replications per hybrid. Diseases were rated at R5.5, using a 0–9 scale, where the most severe disease from the ear leaf to the top of the canopy received a rating of 9. The trial at Stuttgart was terminated due to an accidental and damaging herbicide application. Plots were harvested with a combine equipped with a research weigh system on 18 and 16 September, at Marianna and Kelso, respectively. All disease ratings were recorded by plot, treated as ordinal data, and rank-transformed prior to analysis. Yield data were standardized to 15.5% moisture content prior to analysis and recorded as bushels per acre (bu./ac). Both yield and disease data were subjected to analysis of variance, and when appropriate, the means were separated using Fisher's least significant difference test ($\alpha = 0.05$). Pearson's correlations were completed for each disease and yield at each location to determine which disease, if any, might influence yield differences among hybrids.

Results and Discussion

Disease levels at both locations could be summarized as low to moderate, depending on the disease and location of the trial. At Marianna, there was a correlation between grey leaf spot and yield ($r = -0.15$, $P = 0.19$), indicating that disease had some impact on hybrid yields but was not significantly different by hybrid. This disease is not commonly a problem in Arkansas and is typically found in the northeast corner of the state when it does occur (Faske and Kirpatrick, 2015). This trial was planted behind multiple years of corn, which may have contributed to inoculum carryover and thus influenced the increase in disease severity. The yield range and average for the location were 223.9–146.9 bu./ac and 183.0, respectively (Table 1). At Kelso,

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there was also a relationship between hybrid yield (having a range of 240.8–143.8 bu./ac and average of 191.4 bu./ac) and disease severity, where correlations of southern rust, southern corn leaf blight, northern corn leaf blight, and Curvularia leaf spot were r = -0.22, -0.08, 0.10, and 0.11, respectively (Table 2). Southern rust was most impactful on yield and was significantly different among hybrids (P = 0.0001), indicating variation in hybrid susceptibility to the foliar disease. However, southern corn leaf blight may have had a minor impact on yield differences among hybrids. Yield was also significantly different by hybrid at this location (P = 0.0001).

Disease levels and their impact on yield are largely controlled by hybrid susceptibility and the environment where the corn hybrid is grown. Given this, the rainfall at each location, the time that the rain occurred, and the frequency of the rain help to explain the difference in foliar disease severity and its impact on susceptible hybrids. Rainfall between VT and R5 at Marianna totaled 0.82 inches with an average relative humidity of 67%. Average wind was from the southeast at 124° at 4 mph. Average daily minimum and maximum temperatures were 74.8 °F and 95.4 °F, respectively. Similarly, weather data at Kelso during the same growth stages was 0.50 inches with an average relative humidity of 61%. Average wind was from the southeast at 142° at 4.1 mph. Average daily minimum and maximum temperatures were 75.8 °F and 98.4 °F, respectively. Interestingly, there was significant disease development given the high temperatures and low rainfall at each location.

These trials demonstrated differences in hybrid susceptibility to common foliar diseases in Arkansas, and that disease severity is impacted by environments that differed at individual locations. Some hybrids have more tolerance to diseases that frequently occur in Arkansas, like southern rust (Fig. 1). It is important to understand that when planting corn hybrids that are susceptible to diseases, and the environment is suitable for one or more diseases to develop, fungicide applications may be necessary to help manage the diseases that are identified. Fungicide applications are typically most effective on corn when disease occurs at or before R3 (Kelley and Capps, 2025). Fungicide applications on hybrids known to be susceptible to commonly occurring diseases may not be necessary in all years, as weather is generally not the same from year to year. However, choosing high-yielding disease-tolerant corn hybrids may help simplify the management of foliar diseases in years when the weather is more conducive for disease development and help save the input costs of fungicide applications. For more information on identification and management of corn diseases, consult Chapter 7 Corn Diseases and Nematodes in the Arkansas Corn Production Handbook – MP437 (Faske and Kirpatrick, 2015).

Practical Applications

The results from these trials point to the importance of choosing hybrids that are high-yielding and disease-tolerant in Arkansas growing conditions. When used properly, these data can help farmers avoid unnecessary fungicide applications or better plan for fungicide inputs when hybrids are planted that have higher susceptibility to commonly occurring foliar diseases like southern rust. For recommended fungicide products, please consult the 2026 Arkansas Plant Disease Control Products Guide - MP154 (Spurlock and Faske, 2026).

Acknowledgments

The authors would like to acknowledge support for the project provided by the University of Arkansas Division of Agriculture, Corn and Grain Sorghum Check-Off Funds administered by the Arkansas Corn and Grain Sorghum Promotion Board, and staff at Lon Mann Cotton Research Station and Rohwer Research Station.

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Table 1. Results from a corn hybrid trial at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station at Marianna, Ark., in 2025.

Corn hybrid	Yield	Southern corn leaf blight[†]	Northern corn leaf blight	Southern rust	Curvularia leaf spot	Grey leaf spot
	(bu./ac)					
Axis Seed 64H70RIB Trecepta	201.3	2.0	0.8	4.8	3.8	1.2
Axis Seed 65W75RIB Trecepta	202.5	2.2	1.0	4.2	2.8	0.5
Axis Seed 66Z71RIB Trecepta	175.3	4.0	2.0	4.0	3.8	1.0
Axis Seed 69A79 Trecepta	186.1	0.8	0.0	4.2	4.0	1.2
BH 8727TRE	193.1	2.0	0.0	5.3	2.3	1.7
BH 8939TRE	186.2	2.5	0.5	5.2	4.0	1.2
BH X25003R	170.0	1.0	0.0	6.8	1.5	1.0
CP5682TRE	174.1	1.5	0.0	5.0	2.8	2.5
CP5911VT2P	180.6	1.3	0.0	2.3	5.3	0.7
Crows 5444 VT2P	168.7	1.0	0.7	3.3	5.7	0.0
Crows 5859 VT2P	146.9	2.2	0.0	4.0	4.8	1.2
DEKALB DKC 64-22	194.6	2.0	0.8	1.0	6.0	1.0
DEKALB DKC 66-06	172.9	2.8	0.5	4.8	3.0	2.5
DEKALB DKC 68-35	178.3	2.3	0.3	5.7	3.7	2.3
DEKALB DKC 70-45	178.6	2.0	0.8	4.2	3.2	0.5
Dyna-Gro D52TC66	170.3	2.0	0.5	5.0	1.8	2.2
Dyna-Gro D55TC86	167.6	2.5	0.5	4.8	2.5	0.5
Dyna-Gro D56TC44	176.9	2.8	0.0	6.0	2.8	3.2
Dyna-Gro D58VC74	179.1	1.2	0.2	3.2	5.5	1.0
Dyna-Gro D60TC45	182.8	2.5	1.0	4.8	4.0	0.8
Gateway 2716VT2P	195.1	2.0	0.3	5.3	2.3	0.0
Gateway 3919TRE	188.2	2.2	0.5	2.8	4.0	2.0
Gateway 4914TRE	157.8	1.5	0.0	5.5	4.5	0.5
Innvictis A1254T	196.0	2.2	0.2	4.0	5.0	1.8
Innvictis A1292VT2P	185.8	0.8	0.2	4.8	4.2	1.0
Innvictis A1312VT2P	187.5	3.5	0.2	4.5	2.2	0.0
Innvictis A1414T	184.7	1.8	0.0	5.8	3.8	1.0
Innvictis A1542T	192.9	1.5	0.0	6.0	4.8	0.8
Innvictis A1551VT2P	181.8	2.5	0.0	5.2	3.5	0.8
Innvictis A1792T	163.9	2.8	0.0	3.0	2.5	0.0
Innvictis A1993T	170.6	2.2	0.8	5.0	3.2	1.2
Innvictis ISX1485PWE	208.1	0.8	0.0	5.2	1.5	1.2
Integra 6342 TRE	186.4	1.8	0.0	6.2	3.2	1.2
Integra 6493 VT2P	179.4	1.0	0.0	4.5	5.2	2.0
Integra 6624 TRE	193.5	3.5	0.0	7.0	6.2	0.0
Integra 6915 VT2P	173.5	4.0	1.0	4.5	3.8	0.5
Pioneer P13777PWUE	181.2	2.0	0.2	4.8	3.2	0.8
Pioneer P13841PWUE	223.9	2.8	0.0	6.5	2.0	0.8
Pioneer P14364PWUE	173.4	3.2	0.5	6.8	3.5	0.8
Pioneer P14830VYHR	201.7	1.5	0.0	6.2	2.5	1.8

Continued

Table 1. Continued.

Corn hybrid	Yield	Southern corn leaf blight[†]	Northern corn leaf blight	Southern rust	Curvularia leaf spot	Grey leaf spot
	(bu./ac)					
Pioneer P17677YHR	191.4	1.8	0.0	5.0	4.5	1.0
Pioneer P18216PWE	183.7	1.2	0.2	5.5	3.5	1.0
Pioneer P18986PWE	172.5	1.7	0.3	6.7	1.7	2.7
Progeny PGY 2314TRE	182.6	1.2	1.0	6.0	3.5	1.8
Progeny PGY 2419TRE	177.4	2.7	0.7	6.7	2.3	2.7
Revere 1627 TC	205.0	2.5	0.0	4.5	3.8	1.5
Revere 1839 TC	192.1	2.5	0.0	6.2	3.5	0.5
Mean	183.0	2.1	0.3	5.0	3.5	1.2
CV	13.59	80.9	267.26	34.67	59.22	143.66
PR(>F)	0.0633	0.4293	0.7484	0.0001	0.0899	0.1923
MSE	540.63	2.43	0.81	2.02	4.01	1.67
LSD	26.55	1.78	1.03	1.62	2.29	1.47
Correlation to yield[‡]	1.00	0.04	-0.02	0.11	0.10	-0.15

[†] Foliar diseases were rated using a 0–9 scale where a rating of 9 indicates severe disease at R5.5 from the ear leaf to the top of the plant.

[‡] Pearson's correlation between hybrid yields and disease reactions. A negative correlation indicates that as disease increased, the yield decreased.

Table 2. Results from a corn hybrid trial at the University of Arkansas Division of Agriculture's Rohwer Research Station at Kelso, Ark., in 2025.

Corn hybrid	Yield	Southern corn leaf blight[†]	Northern corn leaf blight	Southern rust	Curvularia leaf spot
	(bu./ac)				
Axis Seed 64H70RIB Trecepta	234.8	2	0.0	4.8	2.5
Axis Seed 65W75RIB Trecepta	176.0	1.2	0.0	5.5	2.0
Axis Seed 66Z71RIB Trecepta	242.5	2	0.0	5.0	2.5
Axis Seed 69A79 Trecepta	228.2	1.8	0.0	3.5	2.5
BH 8727TRE	204.7	1.8	0.0	5.2	2.5
BH 8939TRE	246.5	1.5	0.0	4.8	2.2
BH X25003R	160.8	2.2	0.0	5.5	2.2
CP5682TRE	209.5	1.5	0.0	4.0	2.5
CP5911VT2P	214.2	1.8	0.0	4.8	2.5
Crows 5444 VT2P	221.9	2	0.0	5.5	2.8
Crows 5859 VT2P	232.8	1.2	0.0	4.8	2.8
DEKALB DKC 64-22	215.7	1	0.2	2.2	2.2
DEKALB DKC 66-06	199.0	1.2	0.0	6.2	1.2
DEKALB DKC 68-35	221.2	1.5	0.0	6.0	2.0
DEKALB DKC 70-45	158.0	1.2	0.0	4.5	2.2
Dyna-Gro D52TC66	219.3	0.8	0.0	3.5	2.2
Dyna-Gro D55TC86	199.4	2.2	0.0	5.5	2.0
Dyna-Gro D56TC44	217.8	1.8	0.0	5.2	2.8
Dyna-Gro D58VC74	205.1	1.5	0.0	5.2	2.0
Dyna-Gro D60TC45	231.5	1.5	0.0	4.0	2.2
Gateway 2716VT2P	202.3	2	0.2	4.8	2.2
Gateway 3919TRE	225.0	1.8	0.0	5.0	2.0
Gateway 4914TRE	211.6	1.5	0.0	6.0	1.0
Innvictis A1254T	259.7	2.5	0.0	4.8	2.5
Innvictis A1292VT2P	212.4	2.2	0.0	5.5	1.5
Innvictis A1312VT2P	207.7	2	0.0	6.2	1.8
Innvictis A1414T	224.5	1.8	0.0	5.5	2.0
Innvictis A1542T	201.2	2.2	0.0	5.5	1.5
Innvictis A1551VT2P	221.8	2	0.0	5.8	2.2
Innvictis A1792T	199.1	1.5	0.0	4.2	2.2
Innvictis A1993T	222.8	1.5	0.2	4.8	2.2
Innvictis ISX1485PWE	234.5	1.2	0.0	4.0	1.8
Integra 6342 TRE	245.0	1.8	1.5	5.5	1.8
Integra 6493 VT2P	148.0	2.2	0.0	5.8	1.8
Integra 6624 TRE	200.7	2	0.0	5.5	2.2
Integra 6915 VT2P	191.5	1.5	0.0	5.2	2.0
Pioneer P13777PWUE	219.1	0.8	0.0	4.2	2.0
Pioneer P13841PWUE	243.5	2	0.0	5.0	1.8
Pioneer P14364PWUE	245.2	1.5	0.5	5.0	2.2
Pioneer P14830VYHR	219.3	1.8	0.0	5.5	2.0
Pioneer P17677YHR	160.0	1.5	0.0	6.0	1.8

Continued

Table 2. Continued.

Corn hybrid	Yield	Southern corn leaf blight[†]	Northern corn leaf blight	Southern rust	Curvularia leaf spot
	(bu./ac)				
Pioneer P18216PWE	196.5	2.2	0.0	5.2	2.0
Pioneer P18986PWE	184.9	1.5	0.0	4.2	2.2
Progeny PGY 2314TRE	176.0	2	0.0	5.8	2.2
Progeny PGY 2419TRE	167.6	2	0.0	5.8	2.0
Revere 1627 TC	193.7	1.5	0.0	5.0	2.0
Revere 1839 TC	232.9	1.5	0.0	4.0	2.2
Mean	209.6	1.7	0.1	5.0	2.1
CV	14.68	45.81	822.09	23.53	33.44
PR(>F)	0.0001	0.0138	0.5248	0.0001	0.2953
MSE	374.43	0.38	0.22	0.79	0.47
LSD	19.13	0.61	0.46	0.88	0.68
Correlation to yield[‡]	1.00	-0.15	0.10	-0.22	0.11

[†] Foliar diseases were rated using a 0–9 scale where a rating of 9 indicates severe disease at R5.5 from the ear leaf to the top of the plant.

[‡] Pearson's correlation between hybrid yields and disease reactions. A negative correlation indicates that as disease increased, the yield decreased.

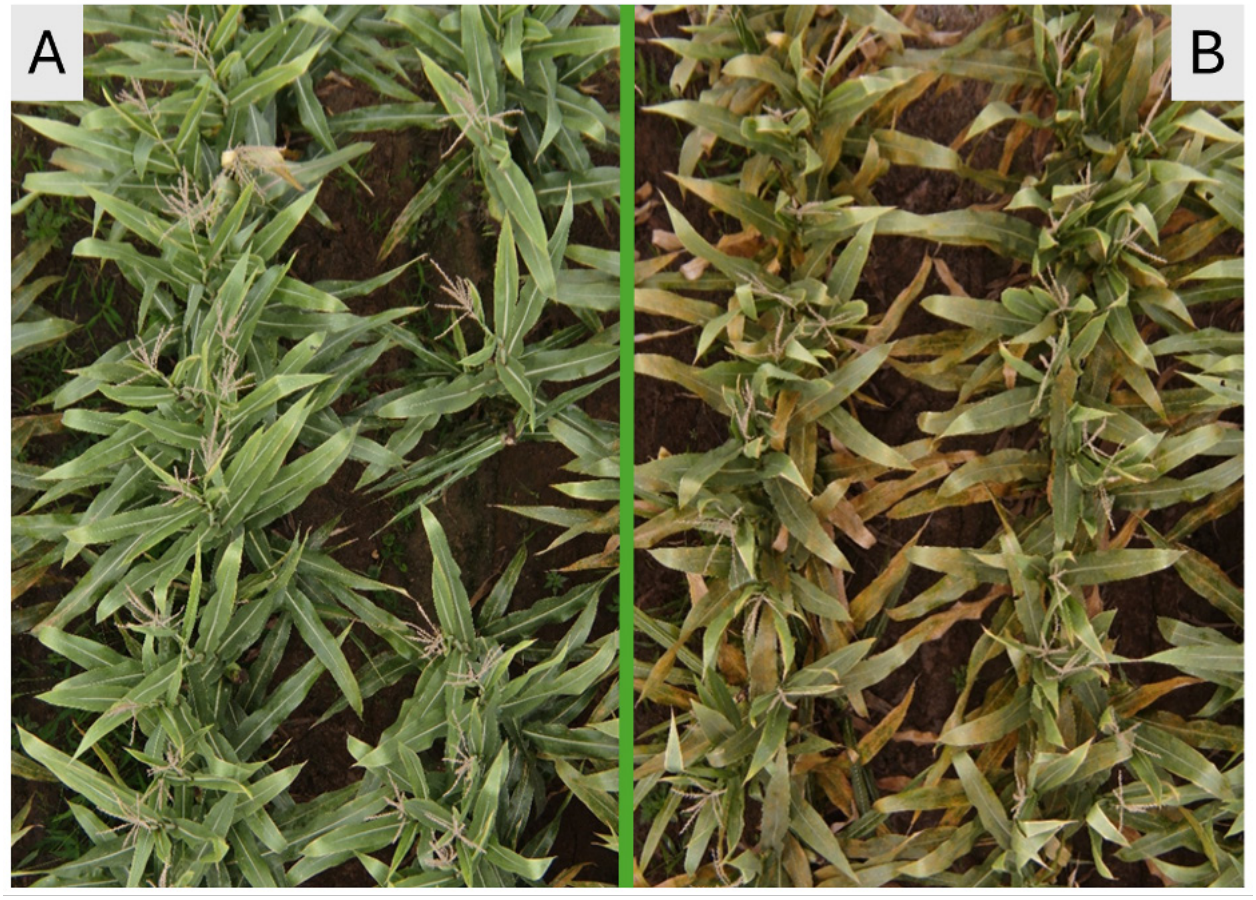


Fig. 1. Two plots from the corn hybrid trial at the University of Arkansas Division of Agriculture's Rohwer Research Station at Kelso, Ark., in 2025. The plot on the left (A) has significantly less southern rust than the plot on the right (B). This demonstrates different levels of hybrid resistance (or susceptibility) to disease.

Efficacy of Fluopyram for Management of Corn Nematodes on Five Hybrids

M.R. Sturdivant,[1] M. Emerson,[1] B. Baker,[1] E.N. Emerson,[1] and T.R. Faske[1]

Abstract

Fluopyram was applied in-furrow, at planting, on five corn hybrids in a field infested with stubby-root nematode (*Paratrichodorus minor*) and lesion nematodes (*Pratylenchus* spp.) in Jackson County. The nematicide had no impact on nematode densities compared to the non-nematicide control across all five hybrids. Likewise, hybrids supported similar densities of both nematode species, indicating that all were susceptible. No yield protection was observed with fluopyram, and grain yield did not differ among hybrids or between nematicide treatments. Overall, these data demonstrate that fluopyram provided little nematode suppression or grain yield protection when nematode densities are low in a loamy sand soil.

Introduction

Several genera of plant-parasitic nematodes are common in corn (*Zea mays* L.) fields in Arkansas. Nematodes most frequently recovered from field corn include stubby-root nematode (*Paratrichodorus minor*), lesion nematodes (*Pratylenchus* spp.), root-knot nematodes (*Meloidogyne* spp.), and stunt nematodes (*Tylenchorhynchus* spp.). Although plant-parasitic nematodes rank among the ten most destructive diseases of corn in the southern U.S. (Mueller et al., 2020), there is little information on the benefit of a nematicide when multiple nematode species are present at densities below a damage threshold for corn.

Over the past fifteen years, the number of nonfumigant nematicides registered for use in corn in Arkansas has increased. Fluopyram is a succinate dehydrogenase inhibitor (SDHI) fungicide, and is among these products, and is marketed as a soil-applied nematicide in corn. It is commercially available as Velum (fluopyram; Bayer, Research Triangle Park, N.C.). Although nematicide efficacy studies on a single corn hybrid have been reported (Emerson et al., 2024; Faske et al., 2023), it is unknown if hybrids respond similarly to fluopyram. Therefore, the objective of this study was to evaluate the field efficacy of fluopyram in suppressing corn nematodes and protecting grain yield potential across five commercially available corn hybrids.

Procedures

The field efficacy of Velum for managing nematodes was evaluated on five corn hybrids in a field experiment conducted in 2025 in Jackson County, Ark. Velum 4.16 SC (fluopyram, Bayer, Research Triangle Park, N.C.) was applied in-furrow at planting at 3.0 fl oz/ac through a 0.07-in.-diameter poly tubing using a pressurized sprayer to deliver a total water carrier volume of 6.5 gal/ac. A non-nematicide treatment served as a control on all hybrids.

Five corn hybrids were planted on 23 April at a seeding rate of 32,000 seed/ac: Dekalb DKC 68-35 VT2 and DKC 65-99 TRE (Bayer, St Louis, Mo.); Pioneer P1511 YHR and P1718 VYHR (Corteva Agrisciences, Johnston, Iowa); Progeny 7115 VT2P (Progeny Ag Products, Wynne, Ark.). The soil was a loamy sand consisting of 78% sand, 18% silt, and 4% clay, and the previous crop was soybean (*Glycine max* [L.] Merr.). The field was irrigated using an overhead pivot irrigation system, and weeds were managed following the University of Arkansas Division of Agriculture's Cooperative Extension Service recommendations.

Plots consisted of four rows, 30-ft long and spaced 30-in. apart. The experimental design was a randomized complete block design with six replications separated by a 5-ft fallow alley. All seeds were treated with a base fungicide, Vibrance Cinco at 1.2 fl oz/cwt (Syngenta Crop Protection, Greensboro, N.C.; the active ingredients are azoxystrobin, mefenoxam, fludioxonil, sedaxane, and thiabendazole at 0.077 mg ai/seed), except for Dekalb hybrids that came pretreated. All seeds were also treated with insecticide, Cruiser 5FS at 0.25 mg ai/seed (Syngenta Crop Protection; the active ingredient is thiamethoxam),

Stand counts (plants per 10 row feet) were recorded 12 days after planting (DAP, 30 April). A vigor rating for each plot was taken at the same time using a 1 to 5 scale, where 1 = poor growth and 5 = best growth. Soil samples consisted of a composite of 8 core samples taken 6 to 8 in. deep and within 3 inches of the plant stalk using a 0.75-in.-diameter soil probe. Samples were collected at planting (23 April by block), mid-season (2 June; 40 DAP at the V7 growth stage by treatment), and at harvest (17 September by block). Nematodes were collected by a modified Baermann pan system and enumerated using an inverted microscope. The two center rows of each plot were harvested with an ALMACO SPC40 plot combine (ALMACO, Nevada, Iowa) equipped with a HarvestMaster Single BDS HiCap HM800 weigh system (HarvestMaster Logan, Utah). Yield data were adjusted to 15.5% moisture. Data were subjected to analysis of variance using IBM SPSS 28.0 (IBM Corporation, Armonk, N.Y.). A significance value of $P = 0.05$ was used.

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Results and Discussion

There was no interaction between nematicide treatments and hybrids for stand counts, seedling vigor, mid-season nematode suppression, or yield, thus, only the main effects are reported. Seedling population at 12 DAP averaged 31,130 plants/ac across hybrids, representing 97 percent stand establishment, and populations were similar between nematicide treatments. Seedling vigor at 12 DAP was similar among hybrids and averaged 2.9. Numerically, vigor was greater for fluopyram-treated plots across hybrids, averaging 3.0 compared to 2.7 in the non-treated control.

Nematode densities at mid-season (40 DAP) were low and similar across hybrids for both stubby-root and lesion nematode, averaging 2 and 71 nematodes/100cm^3 soil, respectively (Fig. 1). These similar densities indicate that all were equally susceptible to both nematode species. No suppression of nematode densities was observed with fluopyram for either nematode species compared to the non-nematicide-treated control. Because soil samples were processed using the Baermann pan method, lesion nematode densities are likely underestimated, as the endoparasitic pest is often found inside the roots rather than in the soil. Regardless, any benefit of a nematicide would be observed in yield protection (Fig. 2). However, there was no yield benefit from fluopyram observed, with both treatments averaging 150 bu./ac. These results align with previous studies reporting minimal yield protection when nematode densities are low (Emerson et al., 2024; Faske et al., 2023). Overall, the relatively low yield observed in the experiment may have masked any potential effects of the nematicide or differences in hybrid yield.

In conclusion, all hybrids respond similarly to fluopyram with respect to yield protection. Because nematode densities were low, a nematicide was likely not needed to protect grain yield. Grain yield in this study was likely limited by low soil fertility rather than by nematode pressure. These data highlight the importance of maintaining sound agronomic practices in corn production and sampling fields for nematode levels that exceed damage thresholds.

Practical Applications

Corn hybrids responded similarly to fluopyram under low densities of stubby-root and lesion nematodes. Furthermore, all hybrids were similar in susceptibility to both nematode species, which aligns with the consensus among field crop nematologists that most hybrids are susceptible to nematodes. Because nematicides do not always improve yield, especially when nematode densities are below damaging thresholds, routine use is not warranted in low-pressure fields. According to the Arkansas Nematode Diagnostic Lab, the damage threshold for stubby-root is 40/100 cm^3, and lesion is 250/100 cm^3. These findings reinforce the importance of soil sampling to determine nematode levels before deciding whether a nematicide is justified in corn.

Acknowledgments

Support provided by Arkansas corn and grain sorghum producers through check-off funds administered by the Arkansas Corn and Grain Sorghum Promotion Board. Support was also provided by the University of Arkansas Division of Agriculture.

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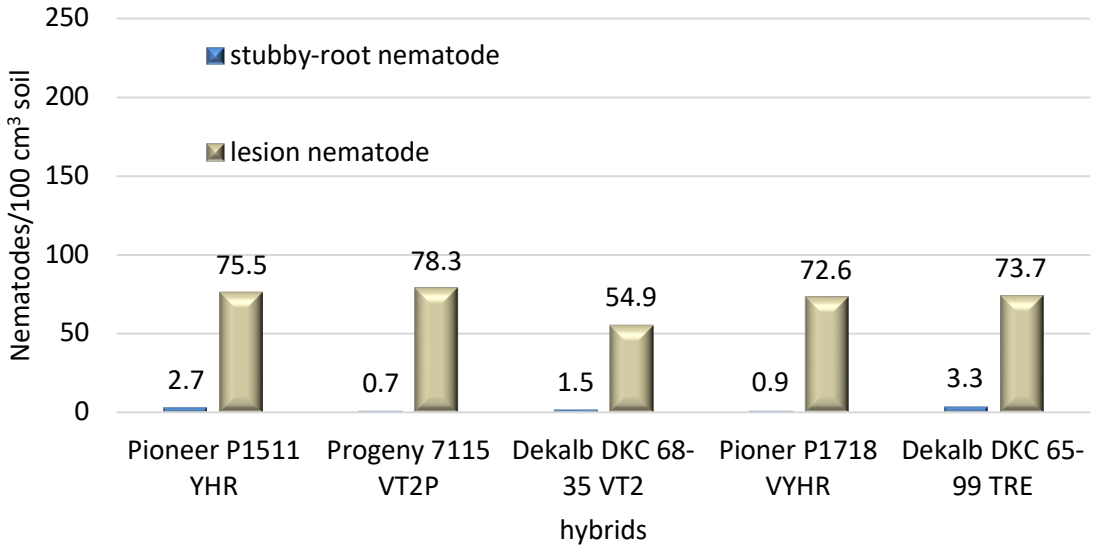


Fig. 1. Population density of stubby-root and lesion nematode at mid-season on five corn hybrids. Each bar represents the average nematode density from four replicates collected 40 days after planting.

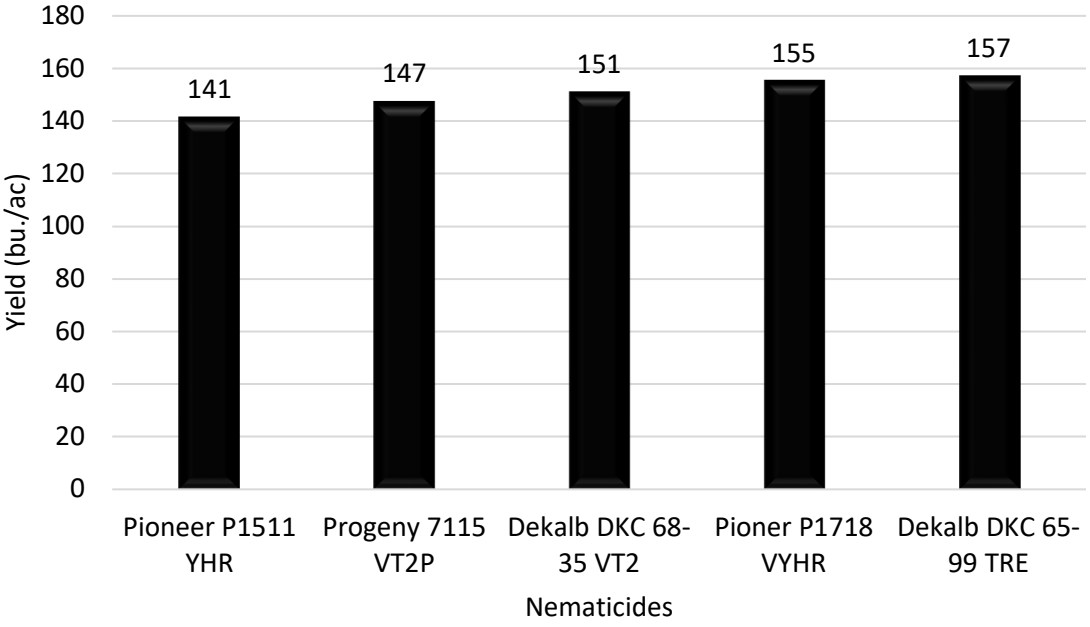


Fig. 2. Grain yield of five corn hybrids grown in a field infested with stubby-root and lesion nematode in Jackson County. Grain yield was adjusted to 15.5% moisture.

Impact of Foliar Insecticide Applications for Control of Corn Earworm in Field Corn

P.G. Maris,[1] N.R. Bateman,[2] B.C. Thrash,[3] S.G. Felts,[2] W.A. Plummer,[3] T. Davis,[3] W.A. Fletcher,[1] J. Linn,[1] and A.C. Graves[1]

Abstract

Throughout the mid-southern United States, corn earworm (CEW) can be found feeding on the foliage and ears of field corn. Though not economically significant in early-planted corn, CEW feeding in late-planted corn can cause yield loss and provide infection courts for fungal diseases. Typically, hybrids expressing *Bacillus thuringiensis* (*Bt*) toxins are planted to prevent yield loss from southwestern corn borer (*Diatraea grandiosella*) and European corn borer (*Ostrinia nubilalis*) and are somewhat effective in suppressing CEW. However, CEW populations have been reported to be resistant to *Bt* toxins, which increases the need for another control method. Three trials were conducted in 2024 and 2025 at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Center and Rice Research and Extension Center to determine if foliar insecticide applications on corn would aid in CEW control and yield protection. No difference in CEW control was observed at three sampling dates between treated and untreated control. Differences in yield protection were observed between treated and untreated plots in one year at one location. These data suggest that foliar insecticides do not control CEW or protect grain yield in Arkansas.

Introduction

Corn earworm (CEW), *Helicoverpa zea*, is a major insect pest of corn, and all life stages are found in Arkansas (McLeod and Studebaker, 2008). Though typically not considered a yield-limiting pest of early planted corn, late-planted corn can experience significant damage from CEW feeding throughout the mid-southern United States (Reay-Jones, 2019). Damage to corn occurs when the immature CEW feeds on corn foliage or tassels at vegetative growth stages (V1-VT) or silks and kernels at reproductive growth stage (R1–R6).

Adult CEW lay eggs on the foliage of young corn plants that develop into the first generation of CEW, whereas later generations develop from eggs laid on the silks emerging from corn ears. Three to four generations can occur each cropping season. Insecticides are often used, when needed, to manage insect pests in row crops. Though an effective tool, foliar insecticides are not an economically feasible method for controlling CEW in field corn (McLeod and Studebaker, 2008, and Studebaker et al., 2026). In addition, foliar insecticides have been shown to increase CEW populations through the elimination of beneficial organisms that transmit naturally occurring insect pathogens, parasites, and predators that naturally suppress CEW populations (McLeod and Studebaker, 2008). Insecticides applied to the seed and soil at planting can provide control of CEW on corn seedlings, but transgenic corn hybrids that express *Bacillus thuringiensis* (*Bt*) toxins are the most effective method. *Bt* genes provide yield protection by reducing CEW feeding on corn foliage and kernels. Though effective, CEW was not the intended target of *Bt* toxins, but instead southwestern corn borer (*Diatraea grandiosella*) and European corn borer (*Ostrinia nubilalis*). Over time, CEW has developed resistance to multiple *Bt* strains in both corn and cotton, which suggests that *Bt* hybrids may need to be treated with an additional insecticide to manage CEW (Yu et al., 2021). Chlorantraniliprole (Vantacor, FMC Philadelphia, Pa.) is a commonly used and effective insecticide used to control CEW on cotton in Arkansas (Studebaker et al., 2026). The objective of this study was to determine if sequential foliar applications of the insecticide Vantacor made on *Bt* and non-*Bt* corn can limit yield loss caused by CEW.

Procedures

Field trials were conducted at the University of Arkansas Division of Agriculture Lon Mann Cotton Research Station in Marianna, Ark., in 2024 and 2025, and the Rice Research and Extension Center near Stuttgart, Ark., in 2025. The corn hybrids used included a non-*Bt*, NK1694 GT at Marianna and DKC68-67 at Stuttgart. Two *Bt* toxin-expressing hybrids were also planted at the Stuttgart location: a Trecepta hybrid, containing three *Bt* toxins, DKC65-99, and a VT Double PRO hybrid, containing two *Bt* toxins, DKC68-35. Plots were four rows wide by 40 ft long and separated by a 10 ft fallow alley. Plots at the Marianna location were planted on 38-in. wide beds, and plots in Stuttgart were planted on 30-in. wide beds. Treatments included between three applications of Vantacor (chlorantraniliprole, FMC Philadelphia, Pa.) at 1.7 oz/ac, and an untreated control. Vantacor applications were made using

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a loader-mounted sprayer on a tractor at 10 GPA. The first insecticide application was made at the R1 growth stage, and subsequent applications were made four and eight days after the initial application. At the Marianna location, treatments were arranged in a randomized complete block design. At the Stuttgart location, strip plots were used where hybrids were planted in strips and treatments were randomized within each strip. All treatments were replicated four times per location per year. The number of CEW per ear on 10 ears was recorded at the Stuttgart location, and the presence or absence of larvae in 10 ears per plot was recorded at the Marianna location. The center two rows of each plot were harvested using an Almaco plot combine, yield was recorded in bushels per acre, and moisture was adjusted to 15.5%. Data were then analyzed using the PROC GLIMMIX function in SAS version 9.4 using a significance level of $P = 0.5$.

Results and Discussion

At the Marianna location, in 2024, all Vantacor treatments had an increase in yield compared to the untreated check; however, no yield differences were observed between one, two, and three applications of Vantacor (Fig. 1). In 2025, no yield differences were observed between treated and untreated plots with an average yield of 109.4 bu./ac. Every corn ear at the Mariana location was completely infested with CEW larva (100%) across all treatments and site years (Fig. 2), indicating a high population density of CEW in that location.

At the Stuttgart location, no differences in yield were observed between treated and untreated plots for any of the three hybrids tested (Fig. 3). Furthermore, no differences in CEW infestation were observed between treated and untreated plots on any of the hybrids (Fig. 4). The hybrid that expressed the Trecepta trait overall had very few CEW per 10 ears compared to the other two hybrids which may be attributed to the additional *Bt* toxin that is expressed by this hybrid. It should be noted that the lack of differences in infestation between treatments within each hybrid could be due to low CEW infestation levels at this location; however, based on the results of the sites conducted at the Marianna location, where the infestation was greater, a yield difference between treatments would not be expected in the case of higher infestation levels.

Practical Applications

A positive yield effect from a foliar insecticide application was only observed in one out of five trials, and no difference in CEW infestation levels was observed between treated and untreated plots. Therefore, foliar insecticide applications are generally not recommended for control of CEW in non-*Bt* or *Bt*-expressing corn hybrids. In the instance that extreme pressure is experienced on very late-planted corn, an insecticide application may be justified. Due to larvae primarily living and feeding in the ears of the corn plant, protected by the husks and deep within the plant canopy, insecticides are unable to reach larvae at a rate concentrated enough to attain adequate efficacy. This issue may be exacerbated when foliar insecticide applications are made using a low-volume spray solution commonly used in aerial applications.

Acknowledgments

The authors would like to thank the Arkansas Corn and Grain Sorghum Board and the University of Arkansas Division of Agriculture for providing support in conducting this study.

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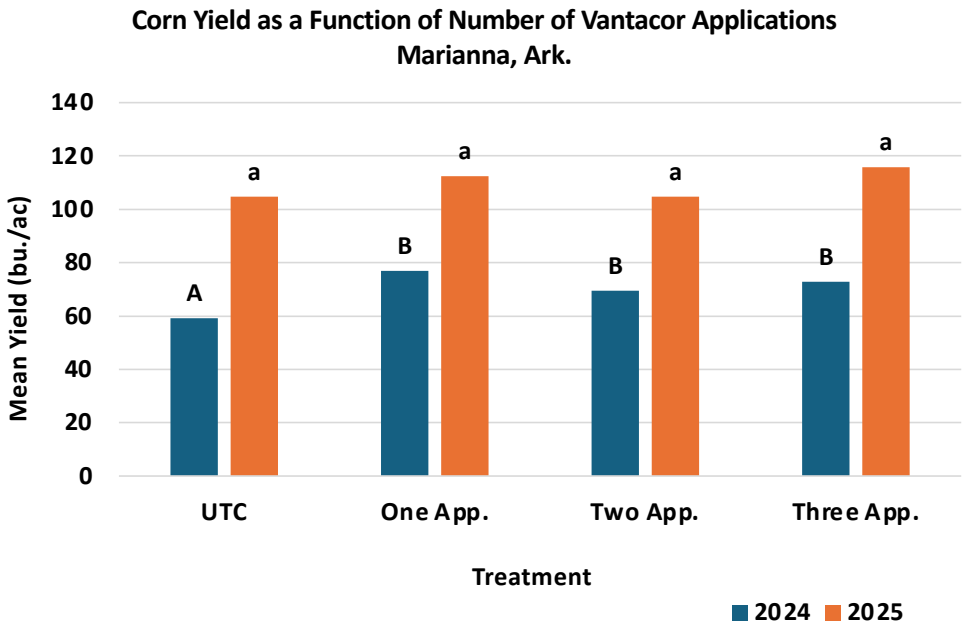


Fig. 1. Effect of one, two, and three treatments of Vantacor insecticide on grain yield at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Center in Marianna, Ark., in 2024 and 2025. Initial insecticide applications were made once plants reached the R1 growth stage. Subsequent applications were made four and eight days after the initial application. Means followed by the same letter are not significantly different at an alpha level of 0.05 according to Tukey's honestly significant difference test.

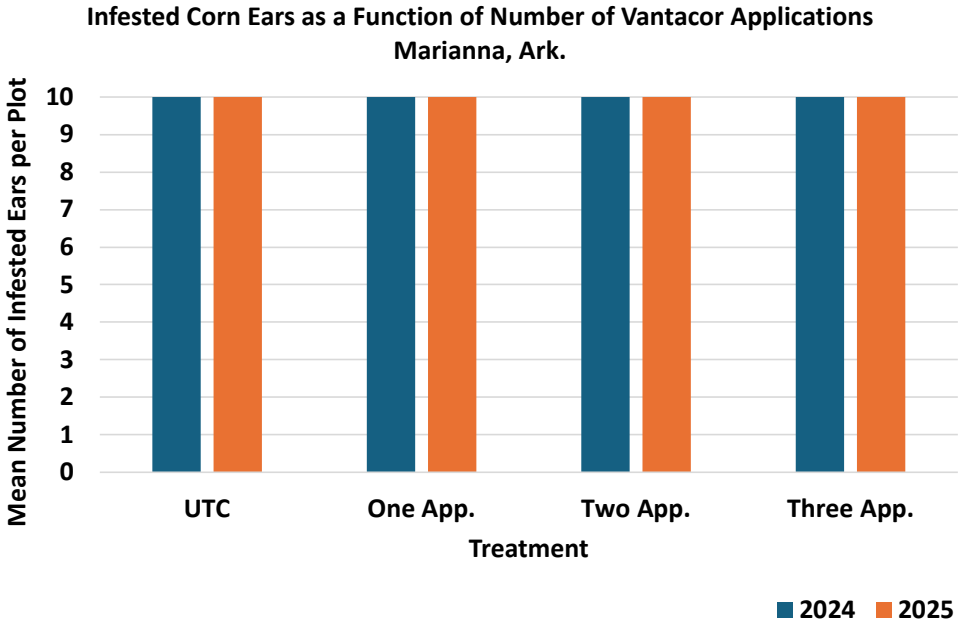


Fig. 2. Corn earworm infestation of corn ears by the number of Vantacor applications at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Center in Marianna, Ark., in 2024 and 2025. Initial insecticide applications were made once plants reached the R1 growth stage. Subsequent applications were made 4 and 8 days after the initial application.

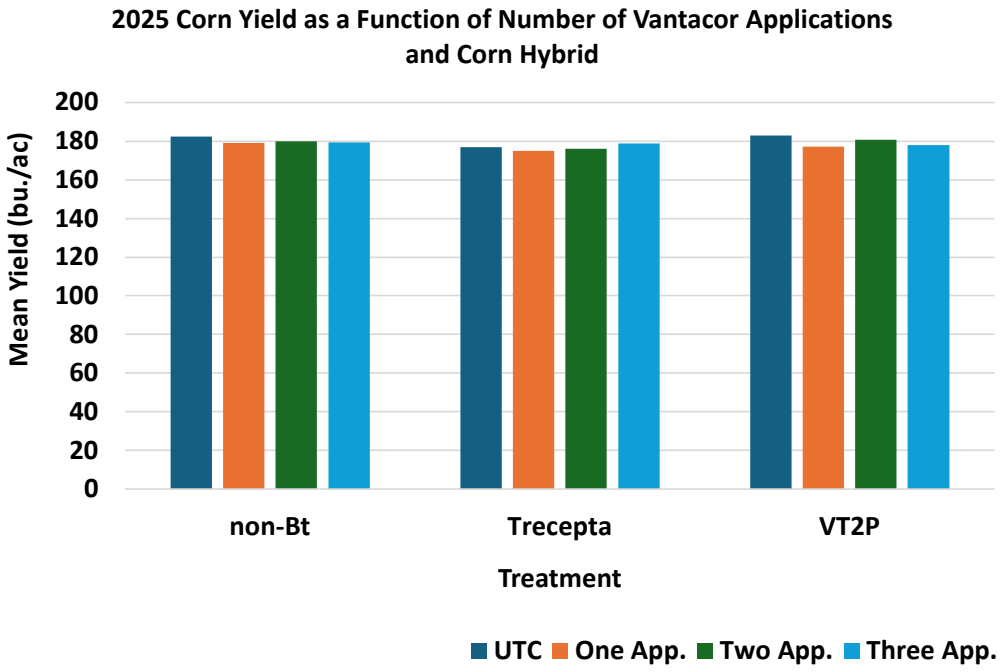


Fig. 3. Effect of one, two, and three treatments of Vantacor insecticide on three corn hybrids at the University of Arkansas Division of Agriculture's Rice Research and Extension Center in 2025. Initial insecticide applications were made once plants reached the R1 growth stage. Subsequent applications were made 4 and 8 days after the initial application.

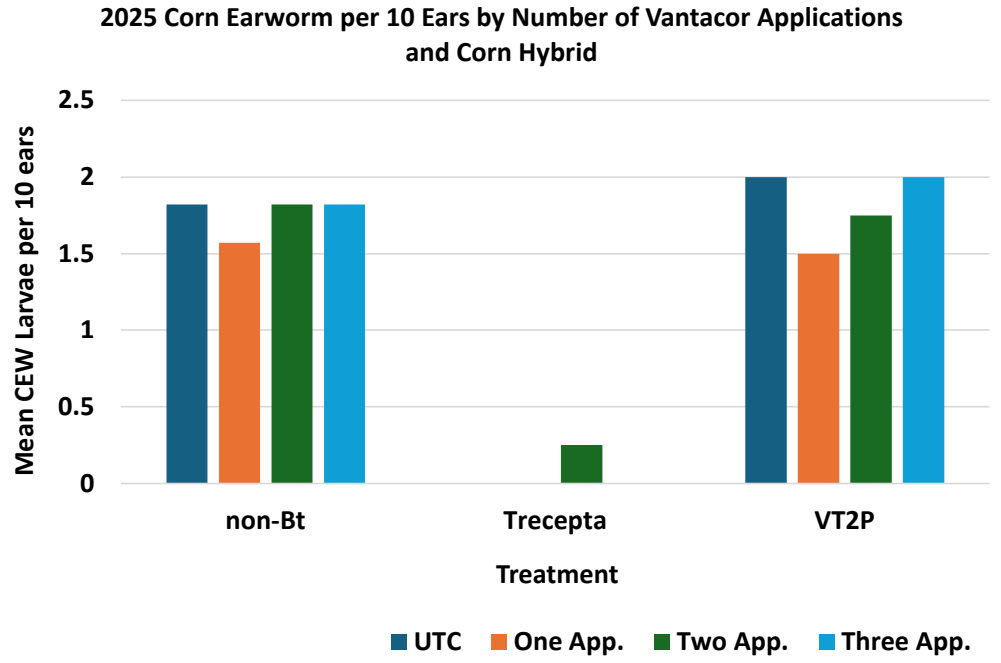


Fig. 4. Mean corn earworms per 10 ears in three corn hybrids at the University of Arkansas Division of Agriculture's Rice Research and Extension Center in 2025 near Stuttgart. Initial insecticide applications were made once plants reached the R1 growth stage. Subsequent applications were made 4 and 8 days after the initial application.

The Impact of Foliar Insecticide Applications in Whorl Stage Corn for Control of Fall Armyworm

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Abstract

Fall armyworm (FAW) is a major insect pest of corn in Arkansas that can infest corn during the vegetative growth stages (V1–VT) and cause significant defoliation, halt apical growth by feeding on the growing point, and allow disease-causing fungi to infect the plant. A threshold of 3–6 FAW larvae per plant is used for non-*Bt* corn. However, there is limited information on foliar insecticides to control FAW. The objective of this study was to assess the efficacy of insecticides to control FAW in corn at the vegetative growth stage (V1–VT). This trial was conducted in 2025 at the University of Arkansas Division of Agriculture's Rice Research and Extension Center near Stuttgart, Ark. Corn was treated with Besiege at 10.5 oz/ac when the FAW infestation reached threshold level populations at the V5 growth stage on 22 July 2025, and untreated corn served as the control. No differences in percent infestation were observed at either 4 or 7 days after treatment. At 4 days after treatment, the percent defoliation was lower in treated plots than in untreated plots. Acceptable efficacy was not achieved from the insecticide used. These data suggest that foliar insecticides provide little FAW control at the V5 growth stage of corn in Arkansas.

Introduction

Fall armyworm (FAW), *Spodoptera frungiperda*, is a major crop pest throughout the Western Hemisphere (Clark et al., 2007) and several agronomic crops, including corn (*Zea mays*). In corn, FAW is a pest of vegetative corn and causes damage similar to that of the corn earworm, *Helicoverpa zea*, infestations in the vegetative growth stage (V1–VT) (McLeod and Studebaker, 2008). FAW annually migrates from southern Texas and Mexico to Arkansas. They may infest the corn crop at any growth stage and can cause damage to any aboveground plant tissue, but prefer to feed close to the ears (Pannuti et al., 2016). Planting a corn hybrid that expresses insecticidal proteins is the primary control method for FAW; however, in conventional corn, insecticides are recommended when populations reach 3–6 FAW larvae per whorl. Controlling FAW populations in vegetative corn during the V1–V9 growth stages has been shown to increase plant height, stalk diameter, and plant height, however, limited efficacy has been observed when foliar insecticides are used to control FAW in whorl stage (V1–V10 growth stage) corn (Marenco et al., 1992). Besiege (Syngenta Crop Protection AG, Basel, Switzerland) is an effective product for control of FAW in Arkansas corn when proper coverage is attainable (Studebaker, 2026). The objective of this study was to assess the efficacy of Besiege insecticide at a high output spray solution to determine whether FAW control can be achieved using foliar insecticide application in whorl stage corn (V3–V10).

Procedures

Sweet corn hybrid, Sweet G-90 (Syngenta Seeds LLC., Basel, Switzerland) was planted on 1 July 2025 at the University of Arkansas Division of Agriculture's Rice Research and Extension Center in Stuttgart, Ark. Plots were 2 rows wide by 20 ft long on 30-in. row spacing. Treatments included an untreated check and a foliar application of Besiege, lambda-cyhalothrin + chlorantraniliprole (Syngenta Crop Protection AG, Basel, Switzerland). Insecticide application was made at the V5 growth stage on 22 July 2025. The experimental design was a randomized complete block design with four replications of each treatment. Besiege was applied at 10.5 oz/ac to treated plots using a backpack sprayer calibrated to 10 GPA at 40 psi using TeeJet flat fan nozzles spaced 15 in. apart. Plots were treated at a threshold level of 3–6 FAW per whorl. Damage ratings were taken by removing the innermost leaf from 10 corn plants within each plot, estimating the percentage of leaf material feeding and the number of FAW larvae. Different plants were evaluated for damage at four and seven days after treatment. Larval counts and damage ratings were converted to percentages, comparing treated to untreated plots. Data were analyzed using the PROC GLIMMIX function in SAS v. 9.4 using a significance level of $P = 0.05$.

Results and Discussions

At the time of application, FAW infestation levels were high but common in late-planted corn. FAW damages corn in large population waves, resulting in significant defoliation. This often leads farmers to try controlling the infestation with foliar insecticides. However, there was no difference in FAW infestation levels, both four and seven days after treatment, between the untreated check and Besiege treatment (Table 1). Corn leaf defoliation was significantly lower four days after treatment with Besiege treatment

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than in the untreated check. In contrast, defoliation was similar at seven days after planting between treatments.

Practical Applications

Adequate control of FAW was not achieved with a foliar insecticide. Though a reduction in percent defoliation was observed at the four days after treatment sample, no differences were observed between treated and untreated plots three days later (7 DAT). Due to the larvae primarily living and feeding within the whorl of the corn plant, insecticides are not able to reach the pest at a rate concentrated enough to achieve adequate control. Therefore, foliar insecticide applications are generally not recommended for control of FAW in vegetative corn growth stage (V1–VT). In very late planted situations, under extreme pressure, an insecticide application may be warranted. Little to no yield loss has been observed outside of this situation. Insecticide coverage may be of even greater concern when insecticide applications are made via drone or airplane, when spray volume is often reduced compared to the higher volumes typically output by a ground application, which was simulated in this study.

Acknowledgments

The authors would like to thank the Arkansas Corn and Grain Sorghum Board and the University of Arkansas Division of Agriculture for providing support in conducting this study.

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Table 1. The efficacy of Besiege for the control of fall armyworm in whorl stage sweet corn at the University of Arkansas Division of Agriculture's Rice Research and Extension Center, Stuttgart, Ark., in 2025.

	Percentage of infested plants		Percent defoliation	
	4 DAT[†]	7 DAT	4 DAT	7 DAT
Untreated check	70 a[‡]	65 a	25 a	30 a
Besiege 10.5 oz/ac	66 a	58 a	15 b	25 a
P-value	0.21	0.14	0.01	0.33

[†] DAT = days after treatment.

[‡] Means followed by the same letter are not significantly different at an alpha value of 0.05 according to Tukey's honestly significant difference test.

Developing Effective Insect Pest Management Strategies for Arkansas Corn

G.E. Studebaker,[1] B. Thrash,[2] and N.R. Bateman[3]

Abstract

Corn production in Arkansas is impacted by a complex of insect pests capable of causing significant economic losses, including soil- and seedling-associated insects, ear-feeding caterpillars, and emerging migratory pests. This research evaluated the effectiveness of insecticide seed treatments and *Bt* hybrid traits for reducing insect injury and preserving yield in Arkansas corn during the 2025 growing season. In addition, statewide monitoring was conducted to assess the distribution of the corn leafhopper. Insecticide seed treatment trials were conducted at three locations using multiple rates of Poncho and Cruiser. Stink bug injury was highest in non-treated plots, while several seed treatment rates reduced early-season damage. The highest rate of Cruiser resulted in the lowest stink bug injury and the greatest grain yield, although yield responses among seed treatment rates were variable, indicating that economic returns may depend on pest pressure and product selection. *Bt* hybrid trials compared non-*Bt*, Double Pro, Trecepta, and VIP traits under early and late planting dates. In early-planted corn, earworm infestation and kernel damage were greatest in non-*Bt* and Double Pro hybrids. Trecepta and VIP traits significantly reduced earworm numbers and kernel injury and produced the highest yields. Late-planted corn experienced increased earworm pressure, particularly in non-Bt hybrids, which sustained the greatest damage and lowest yields. Trecepta and VIP hybrids maintained strong protection and higher yields under late planting conditions. Corn leafhopper monitoring documented widespread presence across Arkansas, with detections occurring in all monitored counties by mid-July. These findings highlight the importance of integrated pest management strategies that include appropriate seed treatment rates, effective *Bt* trait selection, and continued monitoring for emerging pests to support sustainable corn production in Arkansas.

Introduction

Corn production in Arkansas is routinely impacted by a complex of insect pests capable of causing significant economic losses. These pests can be broadly grouped into soil and seedling-associated insects and those that feed on aboveground plant structures, including whorls and ears. Injury occurring early in the growing season is often the most important, as damage to seed, emerging seedling roots, and leaves can substantially reduce stand establishment and yield potential. Under heavy infestations, yield losses exceeding 50% have been reported.

The soilborne pest complex affecting corn and grain sorghum in Arkansas includes seed corn maggots, southern corn rootworms, wireworms, and white grubs, which typically attack seeds or roots shortly after planting. In addition, several insects feed on young seedlings, including the stink bug complex, cutworms, and chinch bugs. Among these pests, stink bugs have been the most damaging in recent years, frequently resulting in stand loss and reduced yield potential. Yield losses from soilborne and seedling pests combined totaled over 367 million bushels in 2024 in the U.S. and Canada (Reisig and Sisson, 2025).

Emerging and migratory insect pests also pose an increasing concern for Arkansas corn production. The corn leafhopper was detected in late-planted corn in Arkansas late in the 2024 growing season. This pest is of particular importance because it is a known vector of the pathogens that cause corn stunt disease. Yield losses of up to 30% associated with this pest–disease complex were reported in southern Texas in 2024. Nationwide losses of 832,300 bushels were reported in 2024 (Reisig and Sission, 2025). Although it is believed that the corn leafhopper is unable to overwinter in Arkansas, its detection highlights the need for continued monitoring and evaluation of potential risk.

Management of insect pests in corn commonly relies on insecticide seed treatments for early-season protection and Bt hybrid traits for control of ear-feeding and stalk-feeding caterpillars, including corn earworm, fall armyworm, and corn borers. However, the effectiveness of these management tools can vary based on application rate, planting date, pest pressure, and environmental conditions, making ongoing evaluation under Arkansas production systems essential.

The objective of this research was to evaluate insecticide seed treatments and Bt hybrid traits for their effectiveness in reducing insect injury and preserving yield in Arkansas corn. In addition, the presence of corn leafhopper was monitored across multiple locations in the state. Results from these studies are intended to provide research-based information to support insect pest management decisions for Arkansas producers.

Procedures

The effectiveness of Poncho (clothianidin) and Cruiser (thiamethoxam) insecticide seed treatments was evaluated for

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reduction of insect pest pressure and yield preservation. All trials were planted in 4-row plots in a randomized complete block design with 4 replications. Insecticide seed treatments at low (standard), medium, and high rates were evaluated in replicated small plot trials in three locations (Arkansas, Lee, and Poinsett Counties). Trials were evaluated at two planting dates (one normal planting date, one planted late). Insect pests (stink bugs, cutworms, corn leafhopper, etc.) incidence and damage were rated weekly for the first 4 to 6 weeks after emergence. All treatments were taken to yield harvesting the center two rows using a small-plot combine, with plot moisture adjusted to 15.5%

Different *Bt* hybrid traits were evaluated for their effectiveness against ear feeding caterpillars. Treatments were evaluated, identifying the species present as well as the level of feeding damage inflicted on each trait. Plots were sampled by removing 10 ears from each plot from non-harvested rows at R3 (milk stage), counting the number of caterpillars by species. Kernel damage was assessed at R5 (dent), removing 10 ears per plot from non-harvested rows. Kernels were considered damaged if there was evidence of caterpillar feeding. Plots were taken to yield by harvesting the center 2 rows of each plot with a small plot combine.

Presence of corn leafhopper was monitored across multiple locations (Miller, Lafayette, Little River, Poinsett, Pulaski, Jackson, and Mississippi Counties) throughout the state. Monitoring was accomplished using yellow sticky cards as well as periodic sampling of corn plants for the presence of the leafhopper.

Results and Discussion

Seed Treatment Study

Results from the insecticide seed treatment rate study at the Poinsett County location (insect damage was extremely low at the other locations and is not included) indicate measurable differences in early-season insect injury and yield among treatments (Table 1). Stink bug-damaged plants were greatest on the non-treated control, reaching a level of 7.8 damaged plants per 10 row feet on the last sampling date on V6 corn. Several insecticide seed treatments reduced stink bug injury relative to the non-treated control, although the level of suppression varied by product and rate. Among Poncho treatments, injury was variable and ranged from 4.5 to 7.3 damaged plants per 10 row feet, with the lowest injury observed at the lowest rate (0.25 mg ai/kernel). Cruiser treatments showed a more linear trend, with injury decreasing as application rate increased, and the lowest damage (2.8 plants per 10 row feet) observed with the highest Cruiser rate (1.25 mg ai/kernel). These results suggest that higher-rate thiamethoxam seed treatments can provide improved early-season protection from stink bug injury under Arkansas growing conditions.

Grain yield followed a generally positive response to insecticide seed treatments compared to the non-treated control (Table 1). The non-treated check averaged 264 bu./ac, while treated plots ranged from 271 to 284 bu./ac. The highest yield was observed with Cruiser at 1.25 mg ai/kernel, which also corresponded to the lowest observed stink bug injury. Intermediate yields were observed across Poncho and other Cruiser rates, indicating that yield response was not strictly linear with rate for both products. These findings suggest that while insecticide seed treatments can contribute to improved yield, the magnitude of response may depend on both pest pressure and product rate, as well as active ingredient.

Collectively, these results demonstrate that insecticide seed treatments remain an effective tool for managing early-season soil and seedling pests in Arkansas corn. However, the variability in injury reduction and yield response highlights the importance of continued evaluation of insecticide rates to balance economic return with pest management efficacy.

Bt Hybrid Study

Earworm pressure and kernel damage were greatest in non-*Bt* and in Double Pro hybrids in both early and late planted corn (Table 2). Trecepta and VIP traits significantly reduced earworm numbers and kernel injury compared with non-*Bt* entries. In comparison, on *Bt* traits, Trecepta treatments, no earworms, and minimal kernel damage were observed, while VIP treatment had low earworm counts and no kernel damage. Kernel damage in Double Pro hybrids was similar to that in non-*Bt* hybrids (Tables 2 and 3), but earworm infestations were significantly higher in Double Pro hybrids for the early planting date (Table 2). Yield responses followed a similar trend, with the Trecepta hybrid producing the greatest yield among early-planted treatments, while non-*Bt* hybrids yielded less under higher earworm damage levels.

Late-planted corn experienced increased earworm pressure overall, particularly in non-*Bt* hybrids, which had the highest earworm densities and kernel damage (Table 3). Double Pro hybrids also showed relatively high earworm infestations and kernel injury under late planting. In contrast, Trecepta and VIP traits continued to provide strong protection, maintaining very low earworm numbers and minimal kernel damage. Grain yield in late-planted corn was greatest in VIP and Trecepta hybrids and lowest in the non-*Bt* hybrid that experienced the greatest earworm damage.

Across both planting dates, *Bt* traits containing VIP proteins consistently reduced earworm infestation and kernel damage compared with non-Bt and Double Pro hybrids. Trecepta and VIP traits provided the most reliable control of corn earworm, particularly under increased pest pressure in late-planted corn. These results indicate that *Bt* trait selection remains an important component of integrated pest management for Arkansas corn production, especially when planting is delayed and earworm pressure is higher.

Corn Leafhopper Monitoring

Corn leafhopper monitoring conducted during 2025 documented widespread presence across Arkansas (Fig. 1). The leafhopper was detected in all counties monitored during the second week of July. This broad distribution confirms that corn leafhopper is established across much of the state and represents a potential risk to corn production. The extent of detections highlights the need for continued surveillance and evaluation of management options, particularly given the role of corn leafhopper as a vector of economically important pathogens. The widespread

occurrence emphasizes the importance of early detection and proactive research to understand population dynamics and the seasonal movement of this pest within the state.

Practical Applications

Overall, results from this research indicate that insecticide seed treatments, particularly at higher application rates, can reduce early-season insect injury and may contribute to increased yield. Farmers should consider higher rates in areas with a history of soil-borne and/or seedling pest pressure. Differences among *Bt* traits suggest ongoing evaluation is necessary to monitor effectiveness and potential resistance development, particularly with corn earworm. The widespread detection of corn leafhopper underscores the importance of continued monitoring and adaptive management strategies as pest complexes in Arkansas continue to evolve.

Acknowledgments

The authors would like to acknowledge the Arkansas Corn and Grain Sorghum Board and the University of Arkansas Division of Agriculture for providing support to conduct these studies.

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Table 1. Stink bug damaged plants and yield among different insecticide seed treatments in 2025 in Poinsett County.

Treatment	Rate	Stink Bug Damaged Plants/ 10 Row Feet on V6 Corn	Yield†
	(mg ai/kernel)		(bu./ac)
Non-Treated		7.8 a‡	263.9 a
Poncho	0.25	4.5 bc	270.7 a
Poncho	0.5	7.3 a	275.6 a
Poncho	1.25	5.0 b	278.6 a
Cruiser	0.25	7.5 a	277.7 a
Cruiser	0.5	5.3 b	272.7 a
Cruiser	1.25	2.8 c	283.8 a

† Yields were adjusted to 15.5% moisture.

‡ Means followed by the same letter within a column are not significantly different at $P = 0.10$, Duncan's New Multiple Range Test.

Table 2. Earworm damage and yield among different *Bt* traits in early planted corn across 3 locations in 2025.

Hybrid	Trait	Earworms/ 10 Ears at R3 (milk)	Damaged Kernels/10 Ears at R5 (dent)	Yield†
				(bu./ac)
DKC 65-93	Non-*Bt*	3.0 b‡	12.8 a	225.3 ab
DKC 65-95	Double Pro	9.0 a	11.1 a	227.6 ab
DKC 65-99	Trecepta	0.0 c	0.2 b	258.6 a
NK 1694	Non-*Bt*	4.0 b	15.4 a	205.4 b
NK 1694-3111	VIP	1.0 c	0.0 b	222.9 b

† Yields were adjusted to 15.5% moisture.

‡ Means followed by the same letter within a column are not significantly different at $P = 0.10$, Duncan's New Multiple Range Test.

Table 3. Earworm damage and yield in different *Bt* traits in late-planted plots across 3 locations in 2025.

Hybrid	Trait	Earworms/ 10 Ears at R3 (milk)	Damaged Kernels/10 Ears at R5 (dent)	Yield[†]
				(bu./ac)
DKC 65-93	Non-*Bt*	4.8 b[‡]	19.0 b	240.8 a
DKC 65-95	Double Pro	6.8 ab	18.8 b	242.9 a
DKC 65-99	Trecepta	0.3 c	0.5 c	237.2 a
NK 1694	Non-*Bt*	9.3 a	34.8 a	207.8 b
NK 1694-3111	VIP	0.3 c	0.2 c	248.4 a

[†] Yields were adjusted to 15.5% moisture.

[‡] Means followed by the same letter within a column are not significantly different at $P = 0.10$, Duncan's New Multiple Range Test.

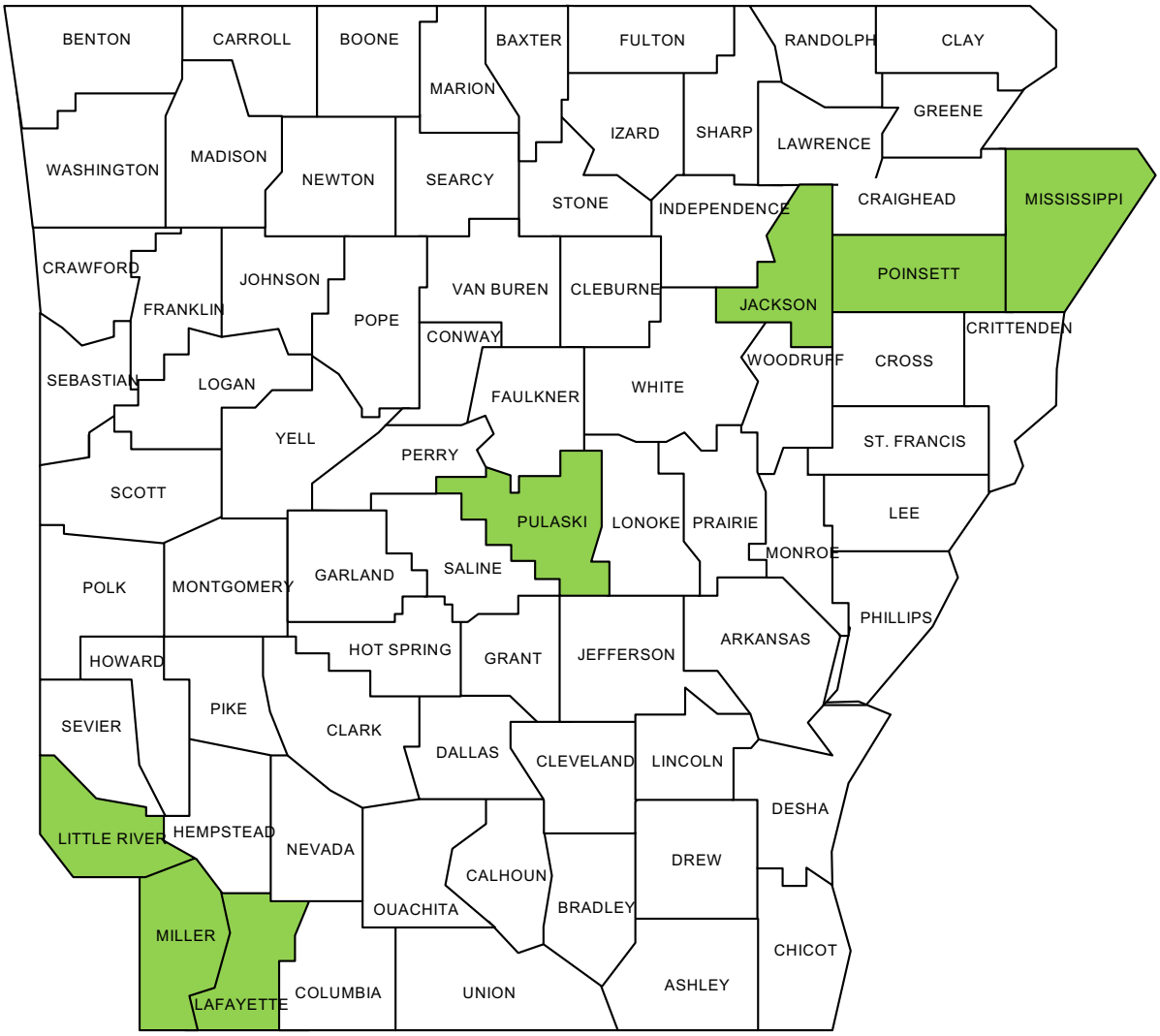


Fig. 1. Corn leafhopper detections by county in 2025. Counties highlighted in green indicate positive detections.

Influence of Corn Stature on Optimum Density for Weed Suppression and Grain Yield Under Irrigated Conditions

H.C. Barber,[1] J.K. Norsworthy,[1] A. Godar,[1] H.R. Rudolph,[1] and L.T. Barber[2]

Abstract

Short-stature corn is a recently developed hybrid that can be planted at higher seeding rates than full-stature corn because of its lower canopy height. Increasing seeding rates may accelerate canopy closure, limit light penetration to the soil surface, and suppress weed emergence. A field study was initiated on 14 April 2025, in Fayetteville, Ark., to evaluate the effects of seeding rate on weed emergence, light interception, and grain yield in short- and full-stature corn hybrids. The experiment was arranged in a split-plot with a randomized complete block design and four replications. Corn stature (short vs. full) was the whole-plot factor, and seeding rate was the subplot factor. Weed emergence from V12 until corn maturity was reduced to <5 plants/10.8 ft^2 at seeding rates of 40,000 seeds/ac or greater compared to 111 plants/10.8 ft^2 in bareground unplanted plots when averaged over both hybrids. At seeding rates below 20,000 seeds/ac, full-stature corn exhibited greater light interception than short-stature corn; however, there were no differences in weed emergence for the main effect of corn stature. Both seeding rate and hybrid stature influenced grain yield. There was a reduction in yield, averaged across both hybrids, with seeding rates ≤ 20,000 seeds/ac yielding less than 209 bu./ac. Averaged over seeding rates, short-stature corn had 24% less grain yield than the full-stature hybrid. Results from this single-year study indicate that short-stature corn shows no advantage in weed suppression or grain yield over full-stature corn at comparable densities; however, an advantage in suppressing weed emergence would likely be seen when a short-stature hybrid is seeded at higher densities than those currently recommended for full-stature corn.

Introduction

Short-stature corn first appeared in the late 1940s from Pioneer (Brummel and Gibson, 2022), but it did not yield as much grain as the full-stature hybrid. These short-stature hybrids are specifically designed to be shorter than conventional corn hybrids, reaching only about 7 ft at maturity (Anonymous, 2018). Although shorter in stature, it is developed to maintain ear size comparable to that of traditional corn. The reduction in height makes short-stature corn more resistant to lodging under high winds and other adverse conditions (Anonymous, 2024). With reduced height, growers will be able to access the corn later in the season for nutrient or crop protection applications using ground equipment, which is often limited to aerial applications (Anonymous, 2018). Because of its lodging resistance, short-stature corn can be planted at higher densities than conventional corn hybrids. In 2023, a Bayer study evaluated seeding rates ranging from 32,000 to 56,000 seeds/ac in Gothenburg, Nebraska, under full irrigation on a silt loam soil to determine which seeding rate produced the highest grain yield. The results indicated that seeding rates from 38,000 to 50,000 seeds/ac optimized yield, producing approximately 240 bu./ac (Anonymous, 2023). The following research was conducted to determine whether corn stature and increased seeding rates influence weed emergence and grain yield.

Procedures

A field experiment was conducted during the summer of 2025 at the University of Arkansas Division of Agriculture's Milo J. Shult Agricultural Research Center in Fayetteville, Ark., to evaluate the impact of plant density on canopy formation, weed emergence, and grain yield of short- and full-stature corn hybrids under irrigated conditions. A conventional full-stature corn hybrid, P13841PWUE, was used for comparison with the short-stature corn hybrid PR111-60RIB (PRECEON). Relative maturity was 113 and 111 days for each hybrid, respectively. Both hybrids were planted on 15 April 2025 and emerged on 24 April 2025. Plots were irrigated and fertilized as recommended based on the University of Arkansas Division of Agriculture's Cooperative Extension Service recommendations for corn. All plots were 12 ft wide by 25 ft long with a 36 in row spacing.

Treatments consisted of seven seeding rates ranging from 15,000 to 45,000 seeds/ac, along with a bareground (not planted) treatment for comparison. Corn density counts were taken two weeks following emergence from two 10.8 ft^2 quadrats/plot. Weed density counts were collected every two weeks from 5 May until harvest using three 10.8 ft^2 quadrats per plot. Following each evaluation, glyphosate at 1.125 lb ae/ac and glufosinate at 0.585 lb ai/ac were applied as an

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overspray treatment to promote additional weed emergence throughout the growing season. Overspray applications were made immediately after weed density assessments at two-week intervals, allowing sufficient time for new weed emergence across different corn growth stages. These evaluations provided insight into weed emergence patterns in relation to soil light penetration throughout the season. Photosynthetically active radiation (PAR) was measured weekly (starting 13 May and continuing until harvest) at solar noon (±45 min) using a 3.3 ft light bar in all plots to determine canopy cover and light interception. Five light readings were taken in between the corn plants, and two readings were taken between the rows for every plot. All readings were taken and averaged to determine full light interception for each plot. The corn was harvested from the middle two rows using a Zurn combine harvester, and the yield was adjusted to 15% moisture content.

Analyses were conducted using RStudio and JMP Pro 19.0. The area under the curve (AUC) for light interception was calculated in RStudio, with a 95% confidence interval. Means were separated using Tukey's honestly significant difference at an alpha value of 0.05. Bareground plots with 0 corn plants were excluded from the light interception and grain yield models. Weed density counts were fit with a negative binomial distribution; grain yield and AUC were modeled as normal. Generalized linear models included hybrids and seeding rates as fixed effects and replication as a random effect.

Results and Discussions

Weed Density

There was no difference in hybrid stature as it related to weed emergence from V12 to physiological maturity (Fig. 1). However, there was a significant effect in terms of seeding rate influencing weed suppression (averaged over stature), with the two highest seeding rates reducing mid-late season weed emergence densities to < 5 plants/10.8 ft^2 in comparison to the bareground plot, which had >110 plants/10.8 ft^2. The weed densities for each seeding rate were averaged over both hybrids. These results, similar to those reported by Teasdale (1995), indicate that corn density was the primary driver of weed suppression, whereas corn stature had no effect. Higher seeding rates promote faster canopy development, thereby reducing light reaching the soil surface and resulting in lower weed populations. To achieve weed suppression, it would be more reliable to increase plant density than to switch hybrids based on one year's data.

Light Interception

Similar to weed density counts, there was no significant interaction between hybrid stature and seeding rates on cumulative light interception (AUC) (Fig. 2). The conventional hybrid intercepted more light at the lower seeding rates, but as the population increased, light interception was similar between the short-stature and full-stature hybrids at ≥ 25,000 plants/ac (Fig 2). There was a strong negative relationship between cumulative light interception (AUC) and weed density. For every 1,000 unit increase in AUC, there was a decline in weed density by 0.51 plants/10.8 ft^2 (Figs. 1 and 2). These results indicate the two hybrids behaved similarly, with the only difference observed in seeding rates. This relationship is similar to the principle that reduced PAR reaching the soil surface limits weed germination and early growth (Ballaré et al., 1990; Teasdale and Mohler, 2000).

Grain Yield

There was no significant interaction between hybrid and seeding rates on grain yield, indicating that the two hybrid types responded similarly across planting densities; however, differences were observed for seeding rates and hybrids separately (Figs. 3 and 4). Yield reduction occurred at seeding rates ≤ 20,000 seeds/ac, with yields falling below 209 bu./ac when averaged across both hybrids (Fig. 3). This confirms that suboptimal plant populations limit yield potential, likely due to reduced ear number per unit area and diminished canopy radiation capture during critical reproductive stages. Across all seeding rates, short-stature corn produced 23.5% less grain yield than full-stature corn hybrids, indicating a consistent main effect of hybrid stature on yield independent of planting density.

Practical Applications

While there has been little research on short-stature corn, it has not shown any comparable difference in weed suppression compared with full-stature corn. The primary driver of improved weed suppression and light interception in corn systems is seeding rate, regardless of hybrid stature. For practical reasons, producers will need to focus primarily on optimizing plant population to maximize early-season canopy closure rather than relying on hybrid stature as a competitive trait. For grain yield, producers will need to plant both hybrids at rates above 20,000 seeds/ac for optimal yields.

Acknowledgments

The authors sincerely thank the Weed Science colleagues and staff at the Milo J. Shult Agricultural Research and Extension Center for their assistance and support in conducting this research. This work represents a contribution of the University of Arkansas Division of Agriculture. Funding for weed management research was provided through check-off funds administered by the Arkansas Corn and Grain Sorghum Promotion Board, and their support is gratefully acknowledged.

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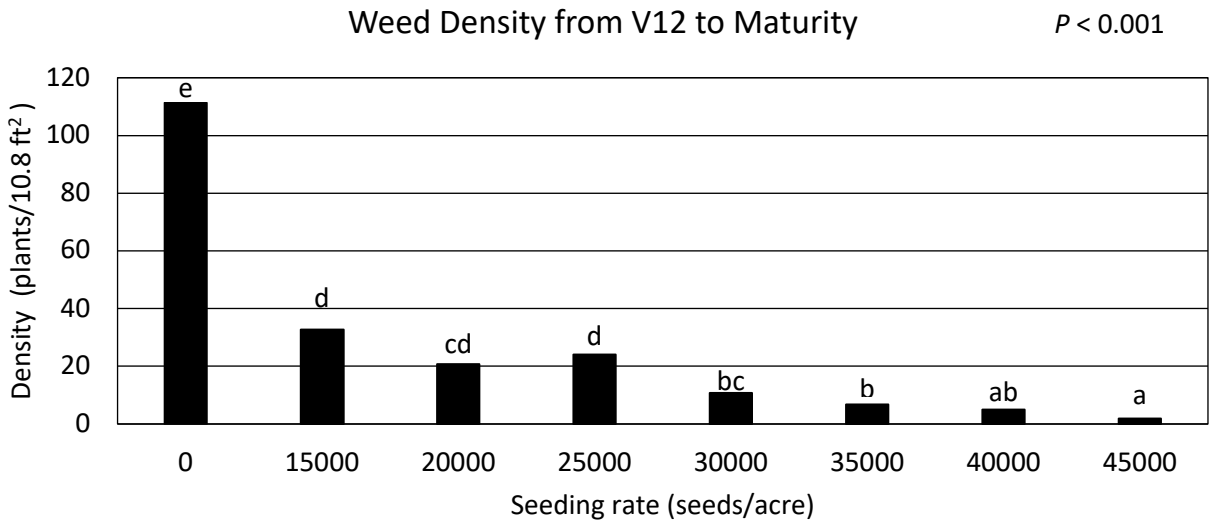


Fig. 1. Fayetteville, Ark, 2025. Densities of total weeds (grasses and broadleaves) from V12 to crop maturity, averaged over corn stature. Means that do not share the same letter are significantly different according to Tukey's honestly significant difference at α = 0.05.

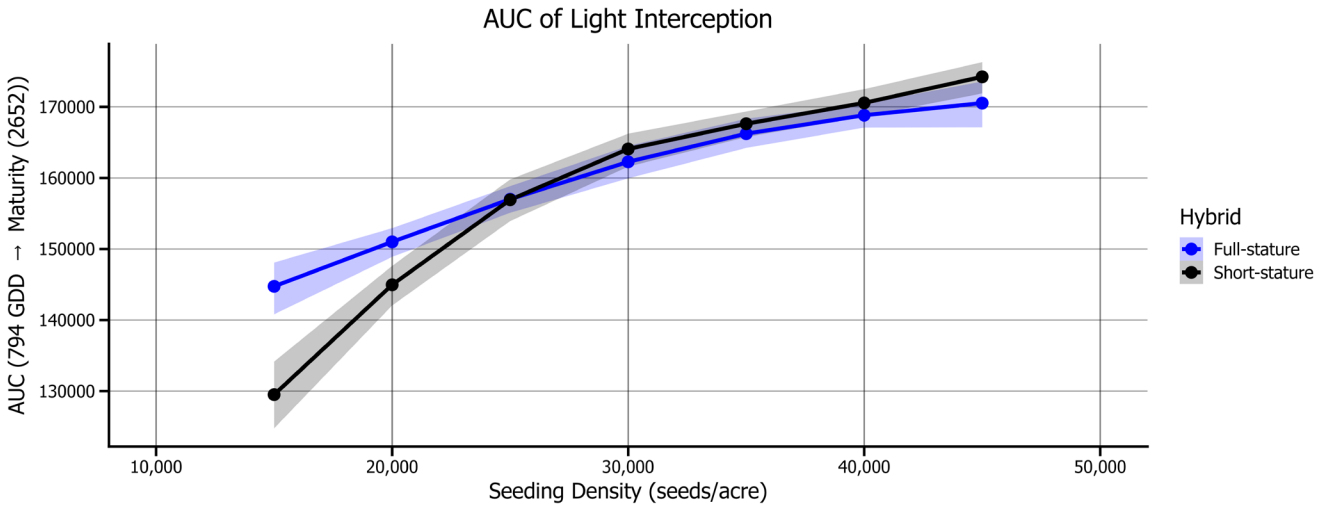


Fig. 2. Fayetteville, Ark, 2025. Area under the curve (AUC) of light interception from V12 (794 GDD) to crop maturity (2652 GDD) for short and full stature hybrids. Transparent shading indicates 95% confidence intervals. GDD = Growing Degree Days.

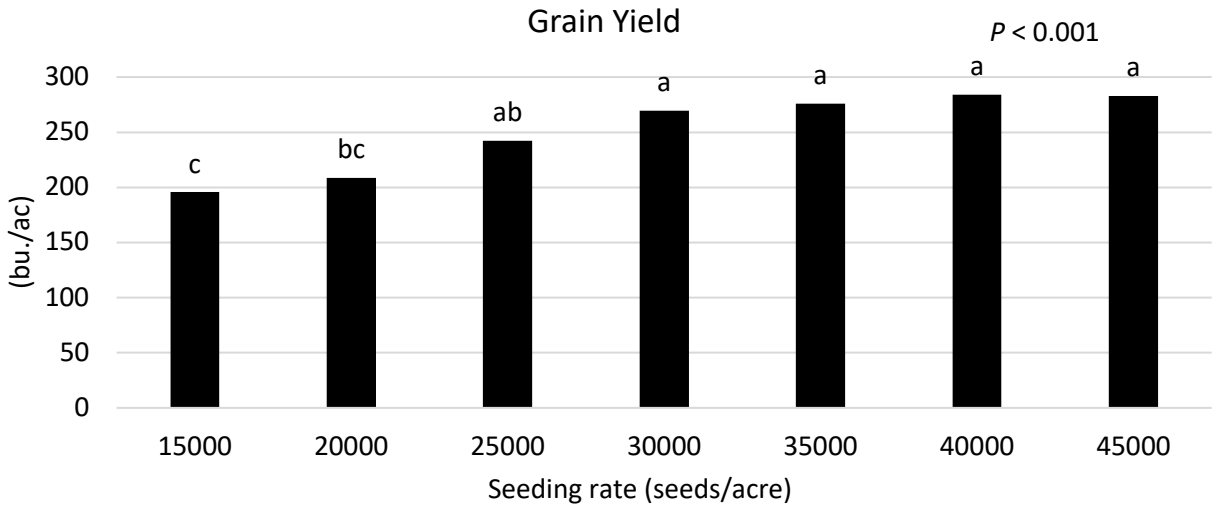


Fig. 3. Fayetteville, Ark, 2025. Grain yield for each seed rate, averaged over plant stature. Means that do not share the same letter differ according to Tukey's honestly significant difference (α = 0.05).

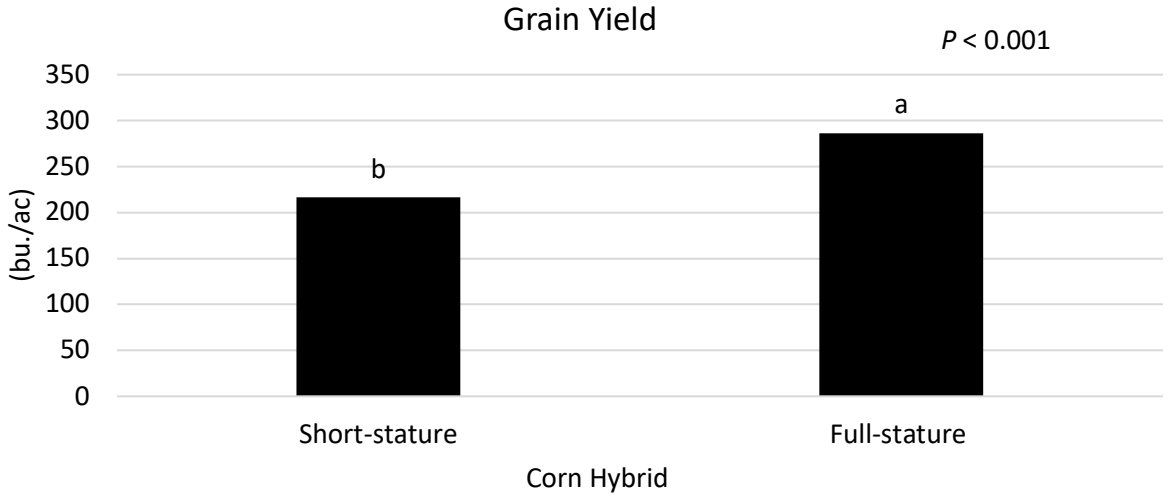


Fig. 4. Fayetteville, Ark, 2025. Corn grain yield by stature, averaged over seeding rates. Means that do not share the same letter differ according to Tukey's honestly significant difference (α = 0.05).

Sensitivity of ArkTam™ and Conventional Grain Sorghum to Soil-Applied Quizalofop

W.T. Herrman,[1] J.K. Norsworthy,[1] A. Godar,[1] L. D. Pierce,[1] and L.T. Barber[2]

Abstract

The ArkTam™ trait in grain sorghum confers resistance to the aryloxyphenoxypropionate class of acetyl-coenzyme A carboxylase inhibitors, chiefly quizalofop. While quizalofop product labels recommend postemergence application for weed control and crop tolerance, the literature shows that the herbicide can safely be used in preemergence mixtures in other crops. During the 2024 and 2025 growing seasons, field studies were conducted in Fayetteville, Ark., to evaluate the tolerance of ArkTam grain sorghum to preemergence applications of quizalofop. A conventional hybrid of grain sorghum was used for comparison. Injury to ArkTam grain sorghum never exceeded 4% in 2024 and 2025. Conventional grain sorghum treated with the highest rate of quizalofop showed high levels of injury at each evaluation timing. In 2024, injury peaked at 58% one week after crop emergence, and, in 2025, injury peaked at 46% at four weeks after emergence, resulting in a 65% relative stand reduction in 2024 and a 47% relative stand reduction in 2025. In addition, 60% relative biomass reduction in 2024 and a 65% relative biomass reduction in 2025 were observed. In 2024, ArkTam grain sorghum displayed an average of 13% relative biomass reduction following quizalofop application, but never showed a relative stand reduction in either year. Despite severe levels of early-season damage, the conventional grain sorghum was able to recover. In both years, no statistical differences existed between relative grain sorghum yields across both conventional and ArkTam grain sorghum. Initial findings show that quizalofop can be applied preemergence in ArkTam grain sorghum and may warrant further evaluation in conventional sorghum systems. These results also likely indicate that ArkTam grain sorghum could be planted immediately after a quizalofop application.

Introduction

The cultivation of a grass crop such as grain sorghum [*Sorghum bicolor* (L.) Moench] entails many challenges, namely the control of weeds. Monocot weeds can have a severe negative impact on sorghum production and yields (Goodrich et al., 2018). Uncontrolled johnsongrass [*Sorghum halepense* (L.) Pers] infestations can cause up to a 90% yield loss in grain sorghum. Even though cultural practices such as tillage and crop rotation are commonly used to control grass weeds in grain sorghum production, an effective herbicide program is still paramount for a successful season (Brown et al., 2004; Abit et al., 2012). Because selective herbicides registered for in-crop use are rare, many growers rely on preemergence (PRE) herbicides for the control of grass weeds. However, if grass weeds escape PRE control or germinate after sorghum emergence, control becomes extraordinarily difficult. Postemergence (POST) options for grass control in grain sorghum are scarce (Abit et al., 2012). When weeds are not promptly controlled, competition with grain sorghum for nutrients, sunlight, and water occurs. This competition can result in drastic yield losses (Oerke, 2006). Furthermore, the presence of weed seeds in the soil seedbank might increase (Espinoza and Kelley, 2004; Norsworthy et al., 2020).

The graminicide quizalofop has typically been used POST to control both annual and perennial grass weeds since the 1980s (Shaner, 2014). In recent years, quizalofop-resistant grain sorghum technologies have been developed. In the spring of 2021, S&W Seed Company (Longmont, Colo.) and ADAMA (Raleigh, N.C.) jointly collaborated and released Double Team™ grain sorghum, the first commercially available quizalofop-resistant grain sorghum technology. Since then, Texas A&M AgriLife Extension Service and the University of Arkansas Division of Agriculture collaborated to create ArkTam™ grain sorghum, another quizalofop-resistant grain sorghum technology with a different mutation than that of Double Team (Norsworthy et al., 2023). While quizalofop is primarily used POST, literature shows that quizalofop can safely be used in mixtures for PRE weed control, can dissipate from soil quickly, and will not runoff or leach (Mantzos et al., 2016; Rosculete et al., 2019; Hazra et al., 2023).

Because of the safe soil characteristics of quizalofop, it could safely be utilized in PRE herbicide mixtures to enhance monocot weed control in ArkTam grain sorghum. Geier et al. (2009) found that grain sorghum treated with certain PRE herbicides exhibited early-season injury, yet the crop recovered by the end of the season. This research was conducted to determine the sensitivity of both ArkTam and a conventional grain sorghum to PRE quizalofop applications.

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Procedures

A field experiment was conducted in 2024 and repeated in 2025 at the Milo J. Shult Agricultural Research and Extension Center at Fayetteville, Ark., to determine the tolerance of an acetyl coenzyme-A carboxylase-inhibiting herbicide-tolerant grain sorghum technology, ArkTam, to PRE applications of quizalofop. A conventional grain sorghum hybrid, 83P73-NS/1, was included alongside the ArkTam for comparison. In 2024, the trial used a hybrid cross of cultivars X21534_ACC/R22281_ACC for the ArkTam grain sorghum. In 2025, a hybrid cross of cultivars X21534_ACC/R22300_ACC was used. Grain sorghum was planted on 28 May 2024 and on 23 June 2025. The later planting in 2025 resulted from excessive precipitation in early summer. A cone planter was used to plant grain sorghum at approximately 90,000 seeds/ac at 3 ft row spacing. Plots were 12 ft by 20 ft in 2024 and 12 ft by 22 ft m in 2025. Plots were irrigated as needed, and nutrients were applied according to the University of Arkansas Division of Agriculture's Cooperative Extension Service recommendations for grain sorghum production.

An overspray application of Dual II Magnum (*S*-metolachlor) at 16 fl oz/ac and AAtrex (atrazine) at 32 fl oz/ac was applied the day before quizalofop treatments. Hand-pulling and hoeing were also implemented throughout the growing season to maintain adequate weed control. Quizalofop treatments consisted of different quizalofop (FirstAct™) rates (Table 1) and were applied PRE to the center two rows of treated plots. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 15 gal/ac at 40 psi.

Visible injury ratings were collected using the Frans and Talbert (1977) method, where 0% represented no visible injury and 100% represented complete crop death (Table 2). Ratings occurred 1, 4, and 6 weeks after emergence (WAE). A stand count in two 3.28 ft sections of treated row was collected at 1 WAE, and two half-meter rows of aboveground biomass per plot were collected at 4 WAE from the same rows. Biomass was dried for two weeks before weighing. Stand count and biomass data were recorded and made relative to the nontreated check in the respective replication. At maturity, grain yield was harvested from the center two treated rows using a small-plot combine and adjusted to 14% moisture, and data were reported relative to each replication's nontreated check (Table 3).

Analyses were conducted in JMP Pro 10 (SAS Institute, Cary, N.C.). Nontreated plots with zero injury were excluded from injury models. Injury data were fit with a beta distribution; relative stand, biomass, and yield were modeled as normal. Generalized linear mixed models included quizalofop rate and sorghum technology as fixed effects and replication as a random effect. Because year effects were significant, analyses were performed separately by year. Means for injury, stand, biomass, and yield were separated using Tukey's honestly significant difference ($\alpha = 0.05$).

Results and Discussion

Visible Crop Injury

In 2024 and 2025, the interaction between quizalofop rate and herbicide-resistance technology was significant at all three rating evaluations (Table 2): 1, 4, and 6 weeks after emergence. In 2024, at 1 WAE, conventional grain sorghum treated with the highest rate of FirstAct (24 fl oz/ac) displayed the highest level of injury (58%). Also at this evaluation, conventional grain sorghum treated with FirstAct at 8 and 12 fl oz/ac displayed 18 and 20% injury, respectively. These injury levels were greater than the injury present in ArkTam grain sorghum (Table 2). At 4 and 6 WAE, conventional grain sorghum continued to display the highest levels of injury, at 41% and 25%, respectively. In 2025, a similar pattern was observed. Conventional grain sorghum treated with FirstAct at 24 fl oz/ac displayed 26%, 46%, and 31% injury at 1, 4, and 6 WAE, respectively. These findings match those of Lancaster et al. (2018), who found that conventional grain sorghum was highly sensitive to soil-applied quizalofop.

In 2024, the effect of technology was significant at all three ratings. Averaged over herbicide rate, at 1 WAE, conventional grain sorghum showed 28% injury, whereas ArkTam grain sorghum did not show any visible injury. In 2024, ArkTam grain sorghum never showed greater than 2% injury. Averaged over quizalofop rate, by 6 WAE, ArkTam grain sorghum showed 0% injury, and conventional showed 2% injury. In 2025, the effect of technology was only significant at the 4 WAE timing, where ArkTam showed 2% injury and conventional sorghum showed 6% injury averaged over herbicide rate.

Quizalofop rate was significant for grain sorghum injury at 4 and 6 WAE in 2024, and at 1 and 4 WAE in 2025. Averaged over herbicide-resistance technology, plots treated with 24 fl oz/ac FirstAct showed statistically higher levels of injury than plots treated with the lower rates (Tables 1 and 2) at 4 and 6 WAE in 2024 and at 1 and 4 WAE in 2025. Injury was 11% at the highest level.

A similar trend was observed in both 2024 and 2025. Plots of conventional grain sorghum treated with FirstAct at 24 fl oz/ac consistently displayed significantly higher levels of injury. ArkTam grain sorghum never displayed more than 4% injury in either year. In both 2024 and 2025, injury from the highest rate of quizalofop to conventional grain sorghum dropped between 4 and 6 WAE (Table 2).

Relative Stand Count, Relative Biomass Weights, and Yield

In 2024 and 2025, the interaction of quizalofop rate and herbicide-resistant grain sorghum technology was significant on relative stand count and relative biomass weights (Table 3). In 2024, conventional grain sorghum treated with FirstAct at 24 fl oz/ac showed a 65% stand reduction, and, in 2025, those same treatments displayed a 47% stand reduction. These treatments also displayed a 60% and 65% biomass weight reduction in 2024 and 2025, respectively.

The effect of herbicide-resistance technology was significant on relative stand count in both 2024 and 2025. Averaged over quizalofop rate, ArkTam grain sorghum did not show stand loss, whereas conventional grain sorghum showed a 27% and 15% stand loss in 2024 and 2025, respectively (Table 3). In both years, the effect of quizalofop rate was significant on relative crop biomass weight. Averaged over herbicide-resistance technology, treatments receiving FirstAct at 12 fl oz/ac showed

an 11% and 13% biomass weight reduction in 2024 and 2025, respectively. Grain sorghum treatments receiving FirstAct at 24 fl oz/ac displayed a 51% and 40% biomass reduction in 2024 and 2025, respectively.

Regardless of herbicide rate and levels of injury present, there was no reduction in the relative yields of both ArkTam and conventional grain sorghum. Both technologies produced good yields. Irrigated grain sorghum yields in the United States have been reported as being upwards of 119 bu./ac (Assefa et al., 2010). Because of season-long irrigation, the yields in this study were not unexpected. However, grain yields were made relative to each replication's nontreated check, and the analyses are presented as such (Table 3).

Grain sorghum has been shown to recover from early-season herbicide injury (Geier et al., 2009). One potential reason for the crop recovery and subsequent lack of yield loss is that grain sorghum can produce more reproductive tillers when plant densities are low (Larson and Vanderlip, 1994; Lafarge and Hammer, 2002).

Practical Applications

While quizalofop is primarily used POST in resistant cropping technologies (Abit et al. 2012; Lancaster et al. 2019), data show that quizalofop could safely be used PRE in quizalofop-resistant grain sorghum such as ArkTam. Quizalofop applied preemergence in ArkTam could offer growers an expanded selection of monocot weed control and increase the window of herbicide application timing to further enhance weed control. Should registration be pursued, this herbicide can be utilized by growers as a control option for early-season perennial and annual grasses, including problematic johnsongrass (Klein and Smith 2020). Control of johnsongrass is paramount in successfully growing a sorghum crop, and quizalofop is an excellent control option (Fleming et al. 2023). Expanding the use window for quizalofop applications in resistant crops will allow growers further opportunities to maintain sufficient weed control.

Acknowledgments

The authors thank fellow Weed Science peers at the Milo J. Shult Agricultural Research Station, as well as station employees, for support in conducting this research. This publication is a contribution of the University of Arkansas Division of Agriculture. Support for weed management research provided through check-off funds administered by the Arkansas Corn and Grain Sorghum Promotion Board is gratefully appreciated.

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Table 1. Experiment treatment structure in 2024 and 2025 at the University of Arkansas Division of Agriculture's Milo J. Shult Agricultural Research and Experiment Station in Fayetteville, Arkansas.[†]

Treatment Number	FirstAct Rate (fl oz/ac)
1	-
2	8
3	12
4	24

[†] All treatments will be applied preemergence. These treatments will be tested on both ArkTam and conventional grain sorghum.

Table 2. Grain sorghum injury as influenced by quizalofop rate and sorghum technology in 2024 and 2025 at the University of Arkansas Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas.[†]

			Injury		
Year	Source	Level	1 WAE	4 WAE	6 WAE
			----------%----------		
2024	Rate[‡]	8	1	1	0
		12	1	4	0
		24	2	11	2
		P-value	0.9290	0.0272	0.0161
	Technol.	ArkTam	0	2	0
		Conv.	28	7	2
		P-value	0.0190	0.0409	0.0003
	Rate*Technol.	8*ArkTam	0 c[§]	1 b	0 c
		8*Conv.	18 b	1 b	0 c
		12*ArkTam	0 c	3 b	0 c
		12*Conv.	20 b	6 b	3 b
		24*ArkTam	0 c	2 b	0 c
		24*Conv.	58 a	41 a	25 a
		P-value	<0.0001	0.0489	0.0161
2025	Rate	8	4	3	2
		12	4	2	0
		24	11	11	9
		P-value	0.0400	0.0067	0.0603
	Technol	ArkTam	4	2	2
		Conv.	8	6	4
		P-value	0.1147	0.0362	0.2495
	Rate*Technol.	8*ArkTam	4 b	3 b	3 b
		8*Conv.	4 b	3 b	2 b
		12*ArkTam	4 b	3 b	1 b
		12*Conv.	4 b	1 b	0 b
		24*ArkTam	4 b	2 b	2 b
		24*Conv.	26 a	46 a	31 a
		P-value	0.0461	0.0013	0.0258

[†] Abbreviations: Technol. = Technology; Conv. = Conventional; WAE = weeks after emergence

[‡] Quizalofop rate expressed in fl oz/ac FirstAct.

[§] Means followed by the same letter within a column are not different based on Tukey's honestly significant difference test (α = 0.05).

Table 3. Relative grain sorghum stand count, biomass weight, and grain yield as influenced by quizalofop rate and grain sorghum technology in 2024 and 2025 at the University of Arkansas Division of Agriculture's Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas.[†]

Year	Source	Level	Relative stand[‡]	Relative biomass[§]	Relative yield
			----------%[#]----------		
2024	Rate[¶]	NT	100	100	100
		8	87	88	106
		12	87	89	96
		24	70	49	97
		P-value	0.0058	<0.0001	0.7598
	Technol.	ArkTam	99	87	95
		Conv.	73	81	105
		P-value	<0.0001	0.1806	0.1971
	Rate*Technol.	NT*ArkTam	100 a[††]	100 a	100
		NT*Conv.	100 a	100 a	100
		8*ArkTam	95 a	92 ab	92
		8*Conv.	79 a	83 bc	120
		12*ArkTam	96 a	79 bc	91
		12*Conv.	77 a	99 ab	100
		24*ArkTam	105 a	58 cd	97
		24*Conv.	35 b	40 d	98
		P-value	0.0009	0.0314	0.5311
2025	Rate	NT	100	100	100
		8	100	98	95
		12	96	87	92
		24	80	60	100
		P-value	0.0923	<0.0001	0.3548
	Technol.	ArkTam	103	105	98
		Conv.	85	69	95
		P-value	0.0044	<0.0001	0.3903
	Rate*Technol.	NT*ArkTam	100 a	100 a	100
		NT*Conv.	100 a	100 a	100
		8*ArkTam	107 a	116 a	96
		8*Conv.	93 ab	80 bc	93
		12*ArkTam	97 a	108 a	89
		12*Conv.	94 ab	66 c	95
		24*ArkTam	106 a	86 abc	107
		24*Conv.	53 b	35 d	92
		P-value	0.0210	0.0098	0.3348

[†] Abbreviations: NT = nontreated; Technol. = Technology; Conv. = Conventional.

[‡] Stand count assessed one week after grain sorghum emergence.

[§] Biomass assessed four weeks after grain sorghum emergence.

[¶] Quizalofop rates expressed in fl oz/ac FirstAct.

[#] Values expressed as a percentage of each replication's nontreated check.

[††] Means followed by the same letter within a column are not different based on Tukey's honestly significant difference test ($\alpha = 0.05$).

Fall Residual Control of Winter Annuals, Yellow Nutsedge, and Bermudagrass

A. Ross,[1] T. Barber,[1] R. Doherty,[2] L. Collie,[1] and Z. Hill[2]

Abstract

Fall-applied residual herbicide programs can have a critical role in establishing and maintaining weed control throughout the growing season. In the fall of 2024, a trial was established at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas, to evaluate herbicide programs applied in the fall and spring prior to planting. Plots measured 12.6 ft by 30 ft and were arranged in a randomized complete block design with four replications. Application times included fall-only (1 November 2024), fall followed by spring (1 March 2025), or spring-only (1 March 2025). Fall-only herbicide treatments included Command (1 pt/ac), Dual Magnum (1.5 pt/ac), Boundary (2 pt/ac), and Dual Magnum (1.5 pt/ac) plus Valor EZ (2 oz/ac). These treatments were repeated and followed with sequential applications of Gramoxone (2 pt/ac) plus Valor EZ (2 oz/ac) on 1 March 2025. A spring-only application of Gramoxone (2 pt/ac) plus Valor EZ (2 oz/ac) was applied for comparison. Visual weed control ratings were collected on 15 March 2025, to evaluate winter annual weeds, and on 1 May 2025, for early germinating summer annuals. Dual Magnum plus Valor EZ applied fall-only provided the greatest control among the fall-only treatments, resulting in 93% control of mayweed (*Anthemis cotula* L.) and 96% control of henbit (*Lamium amplexicaule*). All other fall-only treatments provided 57% or less control of winter annuals. No significant differences were observed in controlling henbit among fall followed by spring treatments. Dual Magnum plus Valor EZ applied in the fall, followed by Gramoxone plus Valor EZ in the spring, provided the most control of mayweed (97%). Fall-applied Dual Magnum plus Valor EZ also provided the greatest control (90%) of spring emerging bermudagrass (*Cynodon dactylon* L.) during May evaluations. Yellow nutsedge (*Cyperus esculentus* L.) control was variable, but the highest control (75%) was achieved with fall-only applied Dual Magnum.

Introduction

Increasing populations of herbicide-resistant winter annual weeds have led Arkansas producers to adopt fall-applied residual herbicide programs to reduce early-season weed pressure and facilitate timely planting opportunities in the spring. Integration of soil residual herbicides is a valuable strategy in reducing the risks of resistance, because residual herbicides minimize weed escapes by providing extended activity (Bagavathiannan, 2013). Fall residual herbicide programs can have a vital impact on starting the planting season weed-free and maintaining control throughout the growing season.

Procedures

This trial was conducted at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas, on a Loring silt loam soil. The experiment was arranged in a randomized complete block design with four replications. Plots measured 12.6 by 30 feet in size. All treatments were applied using a compressed air broadcast sprayer with 11002 Tee Jet Air-Mix nozzles on 19-in. spacing, utilizing 15 GPA carrier volume. Application times included fall-only (1 November 2024), fall followed by spring (1 March 2025), or spring-only (1 March 2025). Fall-only herbicide treatments included Command (1 pt/ac), Dual Magnum (1.5 pt/ac), Boundary (2 pt/ac), and Dual Magnum (1.5 pt/ac) plus Valor EZ (2 oz/ac). These treatments were repeated and followed with sequential applications of Gramoxone (2 pt/ac) plus Valor EZ (2 oz/ac) on 1 March 2025. A spring-only application of Gramoxone (2 pt/ac) plus Valor EZ (2 oz/ac) was applied for comparison.

Visual weed control ratings were assessed on 15 March 2025, to evaluate winter annual weed control, including mayweed (*Anthemis cotula* L.) and henbit (*Lamium amplexicaule* L.), and again on 1 May 2025, to evaluate early germinating summer annuals, including yellow nutsedge (*Cyperus esculentus* L.) and bermudagrass (*Cynodon dactlyon* L.). Data was analyzed using Fisher's protected least significant difference at $P \leq 0.05$ for significance to separate treatment means.

Results and Discussion

Among fall-only applied treatments, Dual Magnum combined with Valor EZ provided the greatest control of mayweed (93%) and henbit (96%). All other fall-only treatments resulted in 57% or less control of winter annuals (Table 1). There were no significant differences observed in the control of henbit among treatments applied in the fall, followed by spring application. Across these treatments (Treatments 6–8), efficacy was observed to be 88% or greater (Table 1). The greatest mayweed control (96%) was achieved utilizing Dual Magnum plus Valor

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EZ applied in the fall, followed by Gramoxone plus Valor EZ applied in the spring (Table 1). Fall-applied Dual Magnum plus Valor EZ (Treatment 4) achieved 91% control of bermudagrass, and control did not improve with a follow-up application of Gramoxone plus Valor in the spring. (Table 2). All other treatments provided 78% control or less of bermudagrass (Table 2). Yellow nutsedge control was greatest (75%) with fall-only Dual Magnum applications and did not improve when followed with a March application. All other treatments resulted in 61% or less control of yellow nutsedge (Table 2).

Practical Applications

Results from this trial suggest a single fall residual herbicide application containing Dual Magnum and Valor can provide needed residual control of mayweed and henbit while also having some activity on early-spring emerging weeds such as bermudagrass and yellow nutsedge. However, the combination of fall and spring applications provides the best opportunity to reduce early-season weed pressure, especially when planting is delayed until May.

Acknowledgments

Special thanks to the University of Arkansas Division of Agriculture and the Arkansas Corn and Grain Sorghum Promotion Board for providing funding for this research.

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Table 1. Visual herbicide efficacy evaluation taken 15 March 2025, to measure the percent control of mayweed and henbit at the University of Arkansas Division of Agriculture's , Lonn Mann Cotton Research Station, Marianna, Ark.

Treatment Number	Treatment Name	Rate per acre	2024/2025 Timing	Henbit Control	Mayweed Control
				----------%----------	
1	Command	1 pt/ac	Nov. 1	77	25
2	Dual Magnum	1.5 pt/ac	Nov. 1	41	15
3	Boundary	2 pt/ac	Nov. 1	46	10
4	Dual Magnum + Valor EZ	1.5 pt/ac + 2 oz/ac	Nov. 1 Nov. 1	97	94
5	Command Gramoxone + Valor EZ	1 pt/ac 2 pt/ac + 2 oz/ac	Nov. 1 March 1	88	45
6	Dual Magnum Gramoxone + Valor EZ	1.5 pt/ac 0.75 + 2 oz/ac	Nov. 1 March 1	99	55
7	Boundary Gramoxone + Valor EZ	2 pt/ac 2 pt/ac + 2 oz/ac	Nov.1 March 1	99	50
8	Dual Magnum + Valor EZ Gramoxone + Valor EZ	1.5 + 2 oz/ac 2 pt/ac + 2 oz/ac	Nov. 1 Nov. 1 March 1	99	97
9	Gramoxone + Valor EZ	2 pt/ac + 2 oz/ac	March 1	99	56
	LSD (P = 0.05)			17.88	32.42

Table 2. Visual herbicide efficacy evaluation (% control) of yellow nutsedge and bermudagrass taken on 1 May 2025 at the University of Arkansas Division of Agriculture's Lonn Mann Cotton Research Station, Marianna, Ark.

Treatment Number	Treatment Name	Rate per acre	2024/2025 Timing	Yellow Nutsedge Control	Bermudagrass Control
				----------%----------	
1	Command	1 pt/ac	Nov. 1	51	73
2	Dual Magnum	1.5 pt/ac	Nov. 1	75	50
3	Boundary	2 pt/ac	Nov. 1	40	44
4	Dual Magnum + Valor EZ	1.5 pt/ac + 2 oz/ac	Nov. 1 Nov.1	56	91
5	Command Gramoxone + Valor EZ	1 pt/ac 2 pt/ac + 2 oz/ac	Nov. 1 March 1	43	40
6	Dual Magnum Gramoxone + Valor EZ	1.5 pt/ac 2 pt/ac + 2 oz/ac	Nov. 1 March 1	39	35
7	Boundary Gramoxone + Valor EZ	2 pt/ac 2 pt/ac + 2 oz/ac	Nov. 1 March 1	54	62.5
8	Dual Magnum + Valor EZ Gramoxone + Valor EZ	1.5 pt/ac + 2 oz/ac 2 pt/ac + 2 oz/ac	Nov. 1 Nov. 1 March 1	61	90
9	Gramoxone + Valor EZ	2 pt/ac + 2 oz/ac	March 1	50	78
	LSD (P = 0.05)			31	22

Results from Eight Years of the University of Arkansas Division of Agriculture Corn Irrigation Yield Contest

C.G. Henry[1] and R. Parker[1]

Abstract

The University of Arkansas Division of Agriculture Irrigation Yield Contest was conducted from 2018–2025. The contest was designed to promote better use of irrigation water, collect data on water use, and efficiency for various crops. Unlike yield contests, where winners are decided by yield alone, the irrigation contest results are decided by the highest calculated total water use efficiency (WUE) achieved by a producer. The contest consists of three categories for crops: corn, rice, and soybeans. All fields entered were required to show a history of irrigation and production on the field. Irrigation water usage was recorded by using 6, 8, 10, and 12-in. portable mechanical flow meters. Rainfall totals were calculated using Farmlogs™. The average WUE for corn from 2018 to 2025 in the contest was 8.86 bu./in. The winning WUE values were 10.55, 11.36, 11.59, 12.53, 7.47, 13.49, 13.51, and 8.83 bu./in. for 2018–2025, respectively. Adoption of irrigation water management practices such as computerized hole selection, surge irrigation, and soil moisture sensors is increasing. Corn contest participants from 2018–2025 reported using, on average, 10.1 ac-in./ac of irrigation water.

Introduction

According to data from 2015 reported by USGS, Arkansas ranks 3rd in the United States for irrigation water use and 2nd for groundwater use (Dieter et al., 2018). For comparison, Arkansas ranked 18th in 2017 in total crop production value (USDA-NASS, 2017). Of the groundwater used for irrigation, 96% comes from the Mississippi River Alluvial Aquifer (Kresse et al., 2014). One study of the aquifer found that 29% of the wells in the aquifer dropped in water levels between 2009 and 2019 (Arkansas Department of Agriculture Natural Resource Division, 2020).

Spencer et al. (2019) conducted a study from 2013 to 2017 in paired commercial corn fields in Arkansas and Mississippi to assess the cost and benefit of 3 irrigation water management (IWM) tools compared to conventional irrigation practices. The study evaluated: computerized hole selection (CHS), surge irrigation, and soil moisture sensors. It was found that the implementation of all 3 IWM tools significantly reduced water applied by 39.5%, increasing corn grain yield by 6.5 bu./ac ($P = 0.0137$) and increased Water Use Efficiency (WUE) by 51% ($P = 0.0062$). The study found that the use of IWM tools increased net returns over the control fields, including the cost of the IWM equipment, from $25.03 to $39.18/ac for pumping lifts of 18 to 400 ft and diesel costs ranging from $1.60 to $3.70/gallon ($P = 0.0115$).

The University of Arkansas Division of Agriculture Irrigation Yield Contest was designed as a novel way to encourage Arkansas Producers to adopt water-saving methods. The competition aimed to promote water-reducing management practices by educating farmers on the benefits of IWM tools, providing feedback on their performance compared to other farmers, documenting the highest achievable WUE in multiple crops under irrigated production in Arkansas, and recognizing farmers who achieved high WUE.

Procedures

Rules for the irrigation yield contest were developed in 2018. Influence was taken from already existing yield contests (Arkansas Soybean Association, 2014; National Corn Growers Association, 2015; University of California Cooperative Extension, 2018). The rules were designed to be as unobtrusive as possible to normal planting and harvesting operations. Fields must be at least 30 acres in size, with a minimum grain yield of 200 bu./ac to qualify.

A portable propeller-style mechanical flowmeter was used to record water use. All flow meters were checked for proper installation and sealed using poly-pipe tape and serialized tamper-proof cables. Rainfall was recorded using Farmlogs™, an online software that provides rainfall data for a given location. Rainfall amounts were totaled from the date of corn seedling emergence to the date of physiological maturity. Emergence was assumed to be 7 days after the planting date provided on the entry form. For physiological maturity, the seed industry's published days to maturity were used. Rainfall was adjusted for extreme events based on rainfall exceeding 2 inches per day for the first thirty days following crop emergence, and three inches per day from 30 days following emergence until crop maturity.

Harvest was monitored by a third-party observer, often an Extension Ag agent, NRCS employee, or a UADA staff member. Grain yield was based on a minimum of 3 acres harvested from the contest field.

Irmak et al. (2006) proposed an equation for calculating WUE:

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$$WUE = \frac{Y}{Pe + IRR}$$

where WUE = Y / (Pe + IRR), WUE = water use efficiency in bu./in., Y = yield estimate from harvest in bu./ac, Pe = Effective precipitation in inches, and IRR = Irrigation application in acre in./ac. This equation was used to calculate WUE in the contest. Statistical analysis was performed using Microsoft Excel and JMP 15 (SAS Institute, Inc., Cary, N.C.).

Results and Discussion

Detailed results are published on the contest website (https://www.uaex.uada.edu/environment-nature/water/agriculture-irrigation/irrigation-contest.aspx) for each year of the contest. Over the last eight years, 68 corn fields have been entered in the contest with an average WUE of 8.86 bu./in. By year, the average WUE was 7.55 bu./in. for 2025 with 7 contestants, 9.98 bu./in. for 2024 with 8 contestants, 9.98 bu./in. for 2023 with 12 contestants, 7.19 bu./in. for 2022 with 5 contestants, 10.53 bu./in. for 2021 with 7 contestants, 8.07 bu./in. for 2020 with 14 contestants, 8.06 bu./in. for 2019 with 9 contestants, and 9.36 bu./in. for 2018 with 6 contestants (Table 1). The average yield in 2025 was one of the lowest for the contest, at 211 bu./ac. The winning WUE in 2025 was 8.83 bu./in. The winning WUE by year was 10.55, 11.36, 11.59, 12.53, 7.47, 13.49, 13.51, and 8.83 bu./in. for 2018–2025, respectively. Total water use in 2025 was the fourth-highest average of 8 contest years.

The authors have observed good results in overall success when a farmer manages the irrigation decision-making, versus an employee with no direct incentive to promote irrigation efficiency. Additionally, previous contest winners tend to do well in the contest with other eligible crops. For example, the 2025 soybean winner won the levee rice division in 2019 and row rice division in 2023. Since 2018, 5 of the 8 winners in the corn category have also won in at least 1 other crop category. These winners confirmed that they were directly involved in the irrigation decision-making process.

In 2015, a survey was conducted across the mid-South to determine the adoption rate of various IWM tools (Henry, 2019). In the survey, 40% of respondents reported using computerized hole selection, while 66% of Arkansas farmers reported using it. Additionally, 24% of respondents said they used soil moisture sensors, whereas only 9% of Arkansas farmers reported using the tool.

A similar survey was conducted for farmers who entered the corn contest. In total, 72% of the participants responded to the questions. The IWM tool that was most widely adopted was CHS. The average use among respondents was 91% across all 8 years, with 83% in 2018, 88% in 2019, 100% in 2020, 88% in 2021, 100% in 2022, 91% in 2023, 100% in 2024, and 86% in 2025. The exception in 2025 was that 1 field was irrigated by center pivot and did not need CHS. This high utilization rate of CHS is clear evidence of farmers' understanding of how critical water management is for corn yield. The second most widely adopted tool was soil moisture sensors, with 62% over the 8 years of the contest reporting using this tool. Average use of moisture sensors was 100% in 2018, 43% in 2019, 50% in 2020, 44% in 2021, 50% in 2022, 92% in 2023, 44% in 2024, and 60% in 2025.

Surge valves were the least used IWM tool, with an 8-year average use rate of 42%. Those that reported using surge irrigation over the 8 years of the contest were 75% in 2018, 0% in 2019, 50% in 2020, 60% in 2021, 100% in 2022, 17% in 2023, 0% in 2024, and 0% in 2025. (Table 2). Adoption rates used in the contest are much higher than reported by Arkansas irrigators.

Practical Applications

Irrigation WUE on working farms is not a common metric reported in the literature, and it is not a metric commonly used or understood by corn farmers. These data provide feedback to farmers on their irrigation performance in maintaining high yield while minimizing water use. This farmer-generated information can offer a competitive advantage as water resources become increasingly scarce. Additionally, it provides a practical framework for farmers to evaluate opportunities for water savings through improved irrigation practices and management strategies.

On average, corn farmers in the contest across the eight years averaged 10.1 ac-in/ac applied and a total water use of 26.6 inches of total water for corn. The WUE of the contest winners improved each year from 2018 through 2021, until 2022, when the lowest WUE was recorded. Upward improvement resumed in 2023 and 2024, each year setting a new winning record. The winning WUE for 2025 was significantly lower than in recent years, which is likely due to above-average rainfall during the growing season.

Acknowledgments

The material is based on work that is supported by the USDA Natural Resource Conservation Service, the Arkansas Corn and Grain Sorghum Board, Seametrics, Valmont-AgSense, Irrometer, Delta Plastics, CropX, Farm Logs, and the USDA National Institute of Food and Agriculture (Project No. ARK02591).

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Table 1. Maximum, average, and minimum for 2018–2025 of various water and yield data points for corn from the Arkansas Irrigation Yield Contest.

Year		Water Use Efficiency	Yield	Adjusted Rainfall	Irrigation Water	Total Water
		(bu./in.)	(bu./ac)	(in.)	(ac-in./ac)	(in.)
2025	Maximum	8.83	250	21.7	17.1	34.1
	Average	9.98	211	18.5	18.5	28.0
	Minimum	2.98	141	16.4	16.4	21.8
2024	Maximum	13.51	285	20.2	60.4	74.2
	Average	9.98	255	16.5	13.8	30.2
	Minimum	2.98	221	13.5	1.1	21.1
2023	Maximum	13.49	272	19.6	18.4	29.7
	Average	9.98	226	13.9	9.4	23.3
	Minimum	8.21	165	10.8	3.2	16.1
2022	Maximum	7.47	212	18	18.8	35.2
	Average	7.19	197	14.1	14	28.1
	Minimum	5.75	183	9.7	8.2	20.9
2021	Maximum	12.53	279	17.3	9.8	25.7
	Average	10.53	243	15.3	7.9	23.3
	Minimum	9.16	216	13.5	5.6	20.6
2020	Maximum	11.59	253	21.4	19.3	33.5
	Average	8.07	211	16.2	10.4	26.6
	Minimum	5.71	155	12.1	2.8	18.8
2019	Maximum	11.36	280	32.6	14.3	43.6
	Average	8.06	233	24.6	6.0	30.6
	Minimum	4.10	179	18.0	1.5	19.5
2018	Maximum	10.55	265	13.1	16.9	29.2
	Average	9.36	216	11.2	12.2	23.4
	Minimum	6.27	160	9.0	8.4	20.3
8 Yr.	Average	8.86	226	16.3	10.2	26.4

Table 2. Irrigation water management tool usage by responding participants for 2018–2025 from the Arkansas Corn Irrigation Yield Contest.

Year	Computerized Hole Selection	Moisture Sensors	Surge Valve
	----------(%)----------		
2025	86	60	0
2024	100	44	0
2023	91	92	17
2022	100	50	100
2021	88	44	60
2020	100	50	50
2019	88	43	0
2018	83	100	75
Average	91	62	42

Corn Plant Water Use and Its Associations with Environmental Drivers During the Critical Periods of High Irrigation Water Requirement

M. Ismanov[1] and C.G. Henry[2]

Abstract

Understanding how environmental drivers regulate corn (*Zea mays* L.) transpiration is critical for improving irrigation efficiency during periods of high crop water demand. This study quantified corn plant water use by growth stage and examined its relationships with soil moisture, solar radiation, relative humidity, wind speed, and temperature during the 2025 growing season at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas. Sap flow, a direct measure of transpiration, was continuously measured in corn planted on two dates (15 April and 16 May) using stem heat-balance sensors, alongside detailed weather and soil moisture monitoring. The measurements show that sap flow exhibited a pronounced diurnal pattern, with 96–97% of total daily water use occurring between sunrise and sunset for both planting dates. Solar radiation and evapotranspiration were the dominant drivers of sap flow, while relative humidity showed a consistent negative association. Wind speed exerted a secondary, positive influence on transpiration. Stratifying sap flow–soil moisture relationships by solar radiation revealed that soil moisture became a critical control only when solar radiation exceeded approximately 600 W m^{-2}, suggesting the onset of water limitation during periods of extreme atmospheric demand, even under calendar-based irrigation. The multi-year average sap flow indicates that about 17.3 in of plant water uptake occurs from V16 to R6, with the highest daily demand during the R1–R2 stages (≈0.38–0.39 in/day). There is considerable variation in water use by growth stage from year to year, requiring multiple years to get a good estimate of water usage.

Introduction

In Arkansas, corn (*Zea mays* L.) producers depend heavily on irrigation because corn is one of the most water-intensive crops grown in the state. During peak water-use periods, the daily irrigation requirement for high-yielding grain corn can reach approximately 0.33 inches per acre, equivalent to nearly 9,000 gallons per acre per day under optimal conditions (Lewis, 2014).

The growth and development of corn are strongly dependent on temperature. Corn develops faster when temperatures are warmer and more slowly when temperatures are cooler. For example, a string of warmer-than-normal days in late spring will encourage leaf development faster than normal (Nielsen R. L., 2020).

Reduced solar radiation during critical growth stages can limit photosynthesis and carbohydrate availability, thereby reducing grain yield and potentially increasing susceptibility to stalk lodging. Low solar radiation (SR) has the biggest effect on yield during silking and grain-fill periods. Experiments that intentionally shaded corn to approximately 50% SR reduced yield by 12–20% when shaded during silking and by 19–21% when shaded during grain fill (Liu et. al. 2009, Reed et. al. 1988)

Average accumulated growing degree days (GDD) were calculated through weekly field visits across all University of Arkansas corn verification fields in 2023 (Capps et al., 2024). The total accumulated GDD at the end of the vegetative stages was 1325, while GDD at physiological maturity (black layer) reached 2861. The accumulation of GDDs can be used to predict corn growth stages and assist in management decisions such as irrigation termination.

Previous work with sap flow or transpiration by growth stages in Arkansas (Ismanov and Henry, 2025a) in 2024 reported that corn, at the beginning of the milk (R3) growth stage, needs 10.8 in. of water, followed by 7.7 in. at the dough (R4) growth stage and 4.9 in. at the dent (R5) growth stage to reach maturity (R6). Ismanov and Henry (2025b) reported that corn plant sap flow for 2023 ranged between 0.1 and 0.5 inches/day during peak water demand periods. For early-planted corn, peak water demand occurred in July, and mid-July to mid-August for mid-season planting and late July to late August for the late planting, respectively. Cumulative sap flow was 22.8, 24.1, and 16.6 inches in early, midseason, and late-planted corn, respectively. Documenting transpiration of crops is useful in developing irrigation scheduling recommendations and other agronomic recommendations.

Procedures

A field irrigation experiment was conducted in 2025 at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas, using Pioneer hybrid P1718VYHR corn (https://www.pioneer.com/) planted in single rows with a 38-in. wide row spacing. The planting dates were 15 April (early) and 16 May (mid-season) 2025. Seeds were sown at a depth of 2.5 inches with a seeding rate of approximately 34,000 seeds/acre. The seeding rate, weed, and insect pest control

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followed the University of Arkansas Division of Agriculture's agronomic recommendations. A John Deere 7300 4-row vacuum planter (https://www.deere.com/) was utilized to ensure precise and efficient seed placement. Each experimental plot consisted of four corn rows and three irrigation rows, arranged so that two central rows received irrigation on both sides, with two alley rows (border) on the outer sides of the plot rows.

The plots were irrigated with a calendar-based method, considered to be well-watered. Irrigation was initiated when the local farmers with similar planting dates began the irrigation, and it continued until crops reached physiological maturity. The Dynamax® Flow 32 1-K system (www.dynamax.com), equipped with Dynagage sensors (model SGB19-WS), was used to measure sap flow, a direct measure of transpiration. This system is attached to corn stalks with diameters ranging from 18 to 22 mm. Data was recorded at 10-minute intervals from 8 plants starting 12 June at the V14 growth stage in early planted corn and on 28 June at the V13 growth stage in midseason planted corn. Measurements continued until harvest days of 4 and 16 September for the early and mid-season planting dates, respectively. Corn plant parameters: plant height, width, number of leaves, and growth stages were measured daily from three plants per plot. The Vantage Pro2 Plus weather station (www.davisinstruments.com) and the ET-Gage (www.etgage.com) were used to record environmental data, solar radiation, wind speed and direction, rainfall, and air temperature. The weather station collects meteorological data and computes reference evapotranspiration (ET_0; hereafter ET) using a Penman–Monteith–type algorithm developed by Davis Instruments. At the same time, the ET-Gage atmometer estimates an alfalfa reference evapotranspiration using the modified Bellani plate method. Soil moisture and in-canopy air and soil temperatures were monitored using an IRROcloud IC-10 Sensor Monitor (Irrometer Co., Riverside, Calif., USA). This device supports up to ten sensor inputs, including six Watermark 200SS soil moisture sensors, a soil temperature probe, and an air-temperature sensor. The IC-10 reads data hourly and transmits via LTE-M cellular directly to the IRROcloud platform, which allows real-time access through a web dashboard or API. The monitor is powered by four C-cell batteries, providing more than two years of operation.

Corn growing degree days (GDD) calculated: GDD = (Daily Maximum Air Temperature + Daily Minimum Temperature)/2 – 50. GDDs are calculated using the daily high and low temperatures, with a maximum temperature of 86 °F and a minimum temperature of 50 °F.

Sap flow, soil moisture, weather, and plant parameter data were analyzed using R-Studio and analysis of variance, Tukey's honestly significant difference post hoc test, Pearson correlation, locally estimated scatterplot smoothing, and polynomial model routines.

Results and Discussion

The temporal dynamics of corn sap flow over a typical two-day period in relation to meteorological variables, including air temperature, relative humidity, solar radiation, evapotranspiration, wind speed, and rainfall illustrated in Fig.1. In each graph, sap flow (left y-axis) is shown concurrently with an environmental variable (right y-axis), allowing direct visual comparison of plant water use responses to changing atmospheric conditions. Sap flow exhibited a pronounced diurnal pattern, characterized by low nighttime transpiration and rapid increases following sunrise. Sap flow showed an inverse relationship with relative humidity. In contrast, solar radiation showed a positive relationship with sap flow, particularly during midday periods when radiation intensity peaked. As expected, the weather station calculated evapotranspiration followed a pattern similar to sap flow. Wind speed exerted a noticeable influence, with modest increases in sap flow during periods of higher wind. In contrast, rainfall events coincided with reductions in sap flow.

Positive correlations were observed between sap flow and air temperature, solar radiation, and evapotranspiration (Fig.2). Among these variables, solar radiation and evapotranspiration showed the strongest correlations with sap flow, highlighting their dominant role in evapotranspiration. In contrast, relative humidity displayed a negative correlation with sap flow. Wind speed exhibited a weaker but generally positive relationship with sap flow.

Sap flow was analyzed for the entire measurement period by partitioning the day into daytime, twilight (morning and evening), and nighttime intervals (Table 1). For corn planted on 15 April, total sap flow was 13.12 gal. per plant, while corn planted on 16 May used 10.34 gal. per plant during the measurement periods. Across both planting dates, the sunrise–to–sunset period dominated water use, accounting for 96.49% of total daily sap flow in the 15 April planting and 96.60% in the 16 May planting. This strong concentration of sap flow during daylight hours reflects the tight coupling between transpiration, solar radiation, and atmospheric demand, confirming that canopy conductance and evaporative forcing are primary drivers of water use.

Nighttime and twilight contributions were minimal. Combined nocturnal sap flow (midnight to twilight start plus twilight end to midnight) represented only 2.69% and 2.51% of daily totals for the 15 April and 16 May plantings, respectively. These small but measurable fluxes likely represent stem refilling and residual transpiration. Morning twilight (twilight start to sunrise) accounted for less than 0.15% of daily water use for both planting dates, while evening twilight (sunset to twilight end) contributed 0.71% and 0.77% for the 15 April and 16 May plantings, respectively. The slightly higher evening twilight contribution suggests continued transpiration after solar radiation declines.

Table 2 summarizes cumulative weather station calculated evapotranspiration (ET) and weather conditions during the late vegetative (V16–VT) and reproductive (R1–R5.75) stages for corn planted on 15 April and 16 May 2025. Total ET during these stages was slightly higher for the earlier planting (10.1 in.) compared with the later planting (9.0 in.). The highest stage ET occurred during the early reproductive stages, particularly R1–R2, when crop water demand and solar radiation were relatively high. Average solar radiation and growing degree days were similar between planting dates, although the later planting experienced slightly higher solar radiation overall (3,165 W m^{-2} cumulative vs. 3,042 W m^{-2}). Relative humidity tended to be higher in the earlier planting, while wind speed was generally lower in the later planting. These results indicate that most crop water use occurred during the reproductive stages under moderate to high

temperature, solar radiation, high wind speed, and low humidity. Consistent with these environmental conditions and ET patterns, plant sap flow was generally higher in the 15 April planting date compared with the 16 May planting date.

Table 3 presents daily and stage-cumulative corn plant sap flow for three growing seasons (2023–2025) and the multi-year average water use from the V16 stage to physiological maturity (R6) for early planted corn. Total cumulative sap flow during these stages was relatively consistent among years, reaching 16.18 inches in 2025, 17.89 inches in 2024, and 17.79 inches in 2023, with a three-year average of 17.29 inches over approximately 58 days.

Daily sap flow generally increased from the late vegetative stages (V16–VT), when values averaged about 0.28–0.32 in./day, to the early reproductive stages. The highest plant water use occurred during the R1 and R2 stages, with average daily sap flow of approximately 0.39 and 0.38 in./day, respectively. These stages also produced the largest stage-cumulative sap flow values, reflecting the period of maximum crop water demand during flowering and early grain development.

After the R2 stage, both daily and cumulative sap flow gradually declined through the grain-filling stages (R3–R5.75) as plant transpiration decreased and the crop approached physiological maturity. Year-to-year variability within specific growth stages is considerable and supports that multiple years are required to develop good average estimates. The multi-year averages suggest that approximately 17.3 in. of plant water uptake occurred between V16 and R6, with the majority of water use concentrated in the reproductive stages.

Practical Applications

Transpiration measurement of corn by growth stage is critical in developing irrigation scheduling tools. Sap flow, i.e. corn plant water use, is strongly concentrated during daylight hours, with 96–97% of total daily water use occurring between sunrise and sunset. Because nocturnal and twilight periods contribute less than 3% of total flow. Plant water demand increased sharply during the reproductive stages, particularly from VT through R3, coinciding with peak solar radiation, evapotranspiration, and rapid GDD accumulation. This period represented the highest risk for water stress and accounted for nearly 40% of total water use to physiological maturity. The multi-year average sap flow indicates that approximately 17.3 in. of plant water uptake occurs from V16 to R6, with the highest daily water demand during the R1–R2 stages (≈0.38–0.39 in/day). Considerable variability from year to year exists in peak water demand and water use for a growth stage, indicating that multiple years of measurements are required for good estimates for developing irrigation recommendations. Good quality estimates of transpiration by growth stage are used for irrigation management decision-making.

Acknowledgments

The authors thank Arkansas corn growers for their financial support of this research through the corn funds administered by the Arkansas Corn and Grain Sorghum Promotion Board. This material is also based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture.

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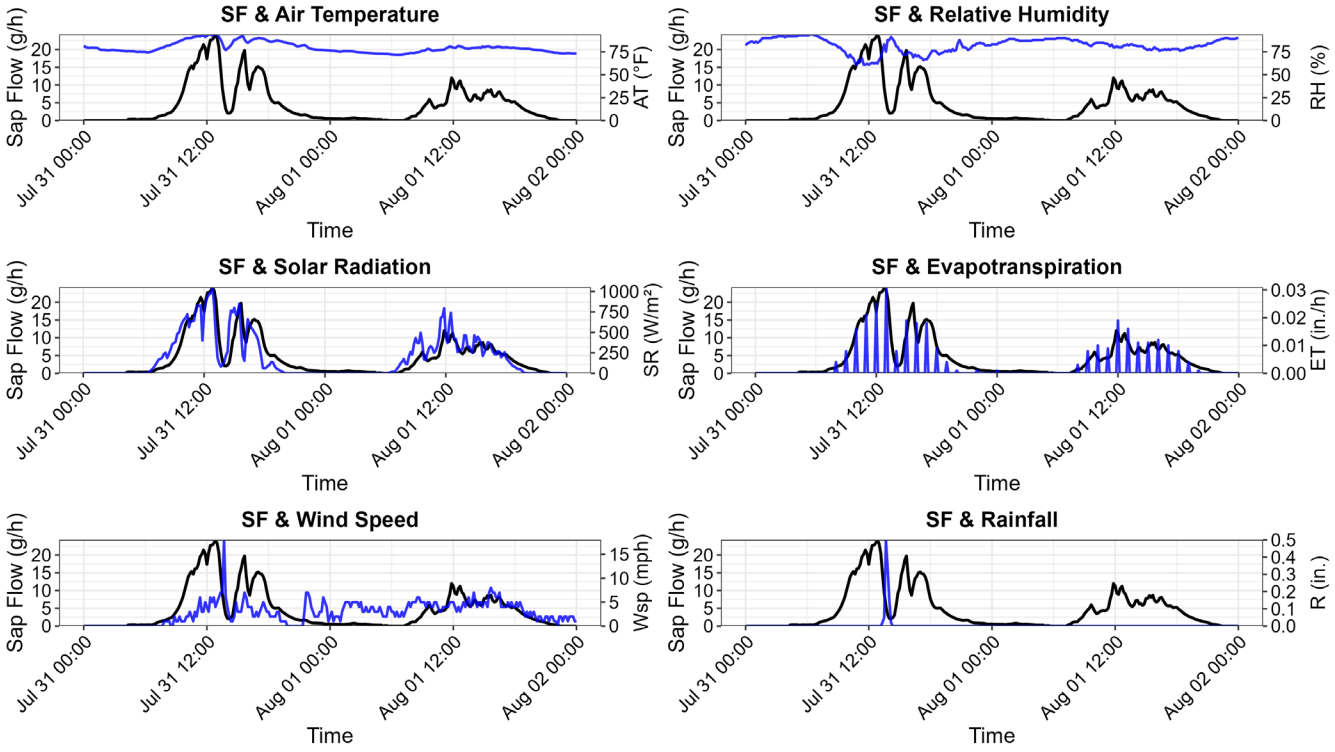


Fig. 1. Two-day sap flow (SF) trends (black line) for mid-season–planted corn (16 May 2025) in relation to air temperature, relative humidity, solar radiation, evapotranspiration, wind speed, and rainfall (blue lines), Marianna, Arkansas.

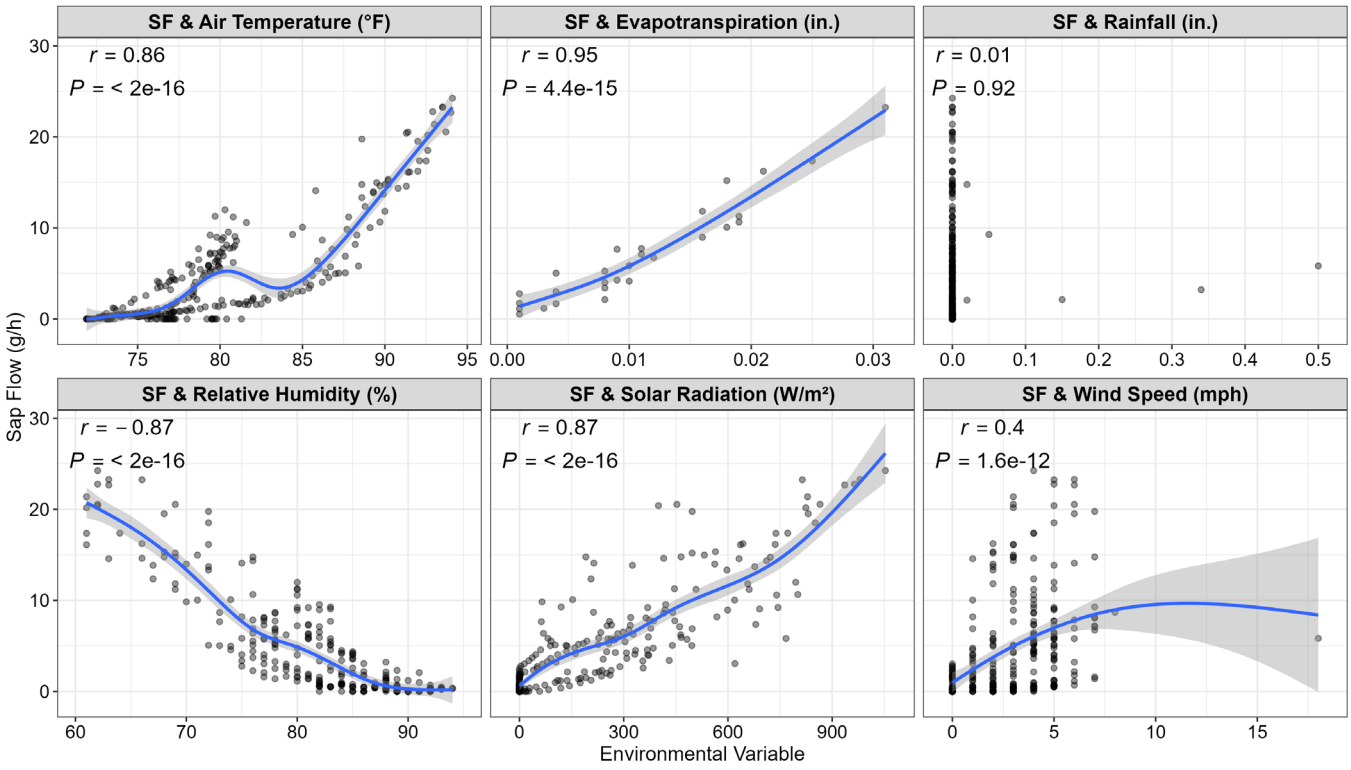


Fig. 2. Relationships between corn plant sap flow (SF) and environmental variables—including air temperature, relative humidity, solar radiation, evapotranspiration, wind speed, and rainfall—modeled using a generalized additive model (GAM) for 31 July and 1 August 2025, for mid-season planted corn, Marianna, Arkansas. The shaded region represents the 95% confidence interval.

Table 1. Distribution of corn plant sap flow across daytime, twilight, and nighttime periods during the measurement period (12 July–4 September and 28 July–16 September) for two planting dates in 2025, Marianna, Arkansas.

	Time intervals	4/15/2025		5/16/2025	
		Gallons	Percentage	Gallons	Percentage
1	Midnight to twilight start	0.017	0.13	0.023	0.22
2	Twilight start to sunrise	0.012	0.09	0.012	0.12
3	Sunrise to sunset	12.679	96.49	9.986	96.6
4	Sunset to twilight end	0.094	0.71	0.079	0.77
5	Twilight end to midnight	0.336	2.56	0.237	2.29
Totals		13.12	100	10.337	100

Table 2. Cumulative calculated daily- average evapotranspiration (ET) from a weather station, average relative humidity (RH), average solar radiation (SR), growing degree days (GDD), and average wind speed (W_{sp}) for two corn planting dates in 2025, Marianna, Arkansas.

	4/15/2025					5/16/2025				
Stages	**ET**	**RH**	**SR**	**GDD**	**W_{sp}**	**ET**	**RH**	**SR**	**GDD**	**W_{sp}**
	(in.)	**(%)**	**(Wm^{-2})**	**(°F)**	**(mph)**	**(in.)**	**(%)**	**(Wm^{-2})**	**(°F)**	**(mph)**
V16	0.3	70	200	28	3.7	0.2	48	312	29	0.7
V17	0.4	68	263	29	3.4	0.2	50	293	28	0.8
V18	0.2	74	222	30	3.3	0.2	49	300	28	0.8
VT	0.4	70	238	29	3.9	0.3	63	224	29	1.4
R1	1.5	62	288	31	1.7	1.3	66	249	29	2.2
R2	2.2	57	283	29	1.7	2.2	60	280	31	1.7
R3	0.8	66	224	29	1.9	0.8	62	264	30	2.5
R4	1	63	271	30	2.2	0.6	55	267	31	1.6
R5	0.9	61	289	31	2.1	0.7	59	243	26	2.5
R5.25	1	61	260	31	1.3	0.8	51	245	28	1.2
R5.5	0.9	59	276	31	2.5	0.8	52	247	29	1.4
R5.75	0.5	63	227	30	2.3	0.8	51	241	29	1.3
Totals	10.1		13,452	1,518		9		11,659	1,317	
Averages*	0.2	82	264	29.7	2.15	0.2	79.6	259	29.3	1.72

*Averages of daily mean values.

Table 3. Daily and stage-cumulative early planted corn sap flow (2023–2025) and multi-year average water requirements from V16 to physiological maturity (R6), Marianna, Arkansas.

	2025		2024		2023		Averages			
Stages	**Daily**	**Stage**	**Daily**	**Stage**	**Daily**	**Stage**	**Days**	**Daily**	**Stage**	**W_{MT}**
	----------(in.)----------									
V16	0.23	0.47	0.33	0.67	0.29	0.58	2.0	0.28	0.57	17.29
V17	0.32	0.65	0.33	0.68	0.30	0.61	2.0	0.32	0.64	16.64
V18	0.17	0.29	0.34	0.69	0.31	0.63	1.7	0.28	0.53	16.11
VT	0.19	0.57	0.35	1.04	0.33	1.30	3.0	0.29	0.97	15.14
R1	0.48	2.56	0.35	1.40	0.33	1.67	5.3	0.39	1.88	13.26
R2	0.45	3.61	0.35	2.44	0.34	2.40	8.0	0.38	2.82	10.44
R3	0.17	1.34	0.33	3.03	0.34	3.07	7.7	0.28	2.48	7.96
R4	0.21	1.62	0.31	2.79	0.33	2.93	7.7	0.28	2.45	5.51
R5	0.27	1.43	0.27	1.65	0.27	1.65	5.3	0.27	1.58	3.94
R5.25	0.30	1.58	0.24	1.44	0.23	1.14	5.3	0.25	1.39	2.55
R5.5	0.25	1.34	0.20	1.18	0.18	1.10	5.3	0.21	1.21	1.34
R5.75	0.15	0.72	0.15	0.89	0.14	0.70	4.7	0.15	0.77	0.57
Totals		16.18		17.89		17.79	58		17.29	

W_{MT} = water to maturity R6.

Evaluating Corn Yield and Water Use Efficiency under Sensor-Guided Irrigation Scheduling using Modified and Current University of Arkansas Division of Agriculture Soil Moisture Sensor Mobile Apps

M. Ismanov[1] and C.G. Henry[2]

Abstract

Sap flow measurements in corn (*Zea mays* L.) at the University of Arkansas Division of Agriculture's (UADA) Lon Mann Cotton Research Station, in Marianna, were used to evaluate yield and water use efficiency (WUE) under irrigation schedules based on varying allowable depletions (AD) thresholds, comparing the current and modified versions of the UADA Soil Moisture Sensor Calculator apps. In the modified app, irrigation was scheduled on a Henry silt loam (PP) soil at 35% and 50% AD thresholds. In the current app, irrigation was scheduled on silt loam with a pan-type soil at 35% and 50% AD thresholds. A calendar-based irrigation method was also included as a control. Corn was planted on 15 April and 16 May 2025, for the AD treatments, while a later planting on 6 June 2025 was used to evaluate only the calendar-based irrigation schedule for yield and WUE. For early and mid-season plantings, calendar-based and 35% AD treatments did not have significant yield differences, but used 20% (35% AD modified) to 40% (35% AD current) less irrigation. Both apps increased water use efficiency (WUE) compared with calendar-based irrigation. In early plantings, 50% AD (both apps) produced the highest WUE, but resulted in a significant yield penalty of 27.4 bu./ac for the 50% AD modified and 19.2 bu./ac for the current 50% AD. WUE and yield were lowest in late-planted corn, reflecting reduced water-use efficiency under shorter growing conditions.

Introduction

Corn (*Zea mays* L.) is a high–water–use crop, and optimizing irrigation scheduling can significantly affect grain yield and water use efficiency (WUE). With growing pressure on water resources in major agricultural regions, effective irrigation management strategies are increasingly critical for improving crop productivity while conserving water. Irrigation scheduling comprises determining the timing and amount of water applied, based on soil moisture, plant growth stage, and climatic conditions. When implemented with precision, this management strategy can improve yield and reduce excess water applications.

In Arkansas, corn farmers rely on irrigation, since corn is among the crops with the highest water demand in the state. For example, during peak water-use periods, the daily irrigation requirement for high-yielding corn may use 0.33 inches per acre—roughly 9,000 gallons per acre per day under optimal conditions (Lewis, 2014). Due to increasing regulatory and resource pressures on water supplies, corn farmers will need to adopt advanced irrigation scheduling methods, including deficit-irrigation strategies. Klocke et al. (2011) reported that a 20 % reduction in irrigation did not cause significant yield differences in corn, pointing to opportunities for improved efficiency.

Modern irrigation scheduling technologies—including soil-moisture sensors, canopy temperature, and evapotranspiration (ET)-based models—show promise for improving water efficiency. However, in practice, the metric "irrigation WUE" is not yet widely reported on working farms and remains difficult for many corn farmers to interpret. Data from the Arkansas Irrigation Contest provides a concrete feedback loop: between 2018 and 2024, the average WUE for corn in those years was 8.88 bu./in. The winning WUE values were 14.09 bu./in. for 2023, 7.47 bu./in. for 2022, 12.53 bu./in. for 2021, 11.59 bu./in. for 2020, 11.36 bu./in. for 2019, and 10.55 bu./in. for 2018 (Henry and Parker, 2024).

Field studies in the region have evaluated irrigation-water-management (IWM) tools. For example, Spencer et al. (2019) conducted a study from 2013–2017 in paired commercial corn fields in Arkansas and Mississippi, comparing conventional irrigation with three IWM tools: computerized hole-selection, surge irrigation, and soil-moisture sensors. Their results indicated that using all three tools reduced water usage by ~39.5%, increased yield by 6.5 bu./ac, and improved WUE by ~51%. Net returns (after including IWM equipment costs) increased by $25.03 to $39.18 per ac, depending on pumping lift and diesel cost (P = 0.0115).

Researchers have emphasized the effectiveness of soil-moisture sensor-based and canopy-temperature-based irrigation scheduling in optimizing WUE (Sui et al., 2012). Such methods are particularly relevant in Arkansas's humid climate, where maintaining adequate soil moisture can prevent water stress. ET-based methods have also been widely studied; they account for crop demand or enable deficit irrigation based on atmospheric and soil conditions (Kisekka et al., 2014). Though calendar-based irrigation remains simple and rooted in farmer experience, it is less precise than sensor- or ET–based methods.

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More recently, comprehensive reviews of precision irrigation technologies highlight their potential to increase WUE, improve yields, and reduce environmental footprint. For instance, Lakhiar et al. (2024) provide a global review of "precision irrigation water-saving systems," including sensor networks, IoT/AI tools, and decision support systems, concluding that water scarcity, technological advancement, and environmental concerns drive adoption of such tools. Similarly, Datta et al. (2023) reviewed soil-water-sensor (SWS)-based irrigation scheduling across cropping systems and found, on average, reductions of ~38 % less water use compared to traditional methods, ~16 % less than computer models, and ~20 % less than standard scheduling models—clearly reinforcing the value of sensor-based approaches.

Despite these advances in irrigation management, there remains a need for region-specific research—particularly in the humid, silt loam, and clay-rich soils of Arkansas—to refine recommendations. Improving irrigation scheduling and planting dates remains essential to further enhance corn yield and water use efficiency in this region.

Procedures

An irrigation experiment was conducted at a 5-acre field of the University of Arkansas Division of Agriculture's (UADA) Lon Mann Cotton Research Station in Marianna, using Pioneer variety P1718VYHR corn seeds (https://www.pioneer.com/) planted in a single-row scheme with 38-inch wide-row spacing. The site is comprised primarily of Calhoun and some Memphis Silt loam and a small area of Calloway silt loam. The planting dates are 15 April (early), 16 May (midseason), and 6 June (late) in 2025. Corn was planted once soil temperatures consistently exceeded 55 °F at 9:00 AM for three consecutive days. Seeds were sown at a depth of 2.5 inches with a seeding rate of approximately 34,000 seeds per acre. The seeding rate, weed, and insect pest control followed the UADA agronomic recommendations. A John Deere 7300 4-row vacuum planter (https://www.deere.com/) was utilized to ensure precise and efficient seed placement. Each experimental plot consisted of four corn rows and three irrigation furrows, arranged so that two central control rows received irrigation on both sides, with two alley rows on the outer sides of the control rows. The length of each plot was 120 feet.

The research evaluated corn yield and water use efficiency (WUE) under different irrigation schedules based on varying allowable water depletion (AD) thresholds, comparing current and modified versions of the UADA Soil Moisture Sensor Calculator App. The current app is available online and requires users to enter the watermark sensor data on soil water status from four depths. The depths used were 6, 12, 18, and 30 inches (Fig.1a). Other data needed for the app include effective rooting depth, soil type, AD, corn growth stage, and planned duration of irrigation hours. The currently available app uses a generic water retention curve for four soil types: sandy loam, silt loam, silt loam with a pan, and clay. For this experiment, the "silt loam with a pan" setting was used, which is similar to the Calloway silt loam. Based on these inputs, the app calculates the average sensor readings, remaining plant available water in the soil profile, the soil moisture threshold at which water stress may occur, the recommended number of days until the next irrigation, and the crop water requirement through maturity (Fig.1b,c–current and modified apps).

The modified app uses a Henry silt loam soil type for the retention curve rather than the generic curve used in the current app. Previous work developing retention curves for soils in Arkansas has created more soil series type-specific curves, and the Henry silt loam curve is most similar to the Calhoun, Calloway, and Memphis silt loam series. Darikandeh et al. (2025) found that for silt loams, the Hyprop+WP4C method produced a better and more conservative relationship for irrigation scheduling than a pressure plate method (the method used for silt loam with a pan). The goal of comparing this modified app was to determine if this retention curve data (the HP+WP4C curve for Henry silt loam) would provide an improvement in yield, water use, and WUE over the current recommendations. The soil retention curve used was the only difference between the two apps.

In the modified app, irrigation was scheduled on a Henry silt loam (PP) soil at 35% and 50% AD. In the current app, irrigation was scheduled on silt loam with a pan-type soil at the same 35% and 50% AD. A calendar-based irrigation method was also included as a control. Corn was planted on April 15 and May 16, 2025, for the AD treatments, while a later planting on June 6, 2025, was used to evaluate only the calendar-based irrigation schedule for yield and WUE.

A total of five irrigation scheduling treatments were evaluated in the early and mid-season planting experiments. In each experiment, the five treatments were replicated three times for a total of fifteen plots per experiment.

1. Calendar-based irrigation,
2. 50% AD using the modified app,
3. 35% AD using the modified app,
4. 50% AD using the current app, and
5. 35% AD using the current app.

In the late planting experiment, one calendar-based irrigation treatment was replicated three times. At planting, Atrazine (2 pt/ac) and Dual Magnum (1.3 pt/ac) (Syngenta) herbicides were applied. When the corn plants reached the V3 to V6 leaf growth stage, Acuron GT (3.75 pt/ac) (Syngenta) and Atrazine (2 pt/ac) were applied using a drop sprayer. Based on soil test results, nitrogen fertilization for the whole season was set at 220 lb N/ac, supplied as 478 lb/ac of urea. The application was split, with one-third of the total N requirement (143 lb/ac of urea with Agrotain) applied at planting. Pre-plant fertilization included 125 lb/ac of ammonium sulfate and 10 lb/ac of zinc.

Soil moisture and associated inner corn row environmental variables, like air and soil temperatures, were monitored using an IRROcloud IC-10 Sensor Monitor (Irrometer Co., Riverside, Calif., USA). This device supports up to ten sensor inputs, including six Watermark 200SS soil moisture sensors, a soil temperature probe, and an air-temperature sensor. The IC-10 reads data hourly and transmits via LTE-M cellular directly to the IrroCloud platform, which allows real-time access through a web dashboard or API. Vantage Pro2 Plus versatile weather station (www.davisinstruments.com) and ET-gage (www.etgage.

com) are used to collect weather data: air temperature, air relative humidity, solar radiation, wind speed and direction, rainfall, and evapotranspiration (ET).

An electric-powered irrigation pump equipped with an automatic switch was used. Adjustable gate valves were used to control the volume of water to maintain AD thresholds.

Water Use Efficiency (WUE) is calculated using the formula (Henry et al., 2025):

$$WUE = \frac{Y}{I + eR}$$

where WUE = water use efficiency (bu./ac/in.), Y = yield estimate from harvest (bu./ac), I = iIrrigation application (in.), and eR = effective precipitation (in.).

The early-planted experiment was harvested on 4 September, midseason, and late-planted corn harvested on 14 September for 143, 122, and 101 days from planting to harvesting for early, midseason, and late planting corn, respectively.

Statistical analyses were conducted using R-Studio, employing analysis of variance to assess treatment effects, and when appropriate, Tukey's honestly significant difference multiple comparison test.

Results and Discussion

Corn emergence was 100% eight days after the 15 April planting, six days after the 16 May planting, and four days after the 6 June planting. Average plant densities were 33.7K, 31.4K, and 33.0K plants per acre for the 15 April, 16 May, and 6 June planting dates, respectively. The lower stand density observed in the 16 May planting can be attributed to some damage to newly emerged plants caused by severe storms in late May.

Calendar-based treatments in early- and mid-planted corn were irrigated for the first time on 26 June. In early-planted corn, irrigation for the 35% AD treatment in the modified app began on 3 July, while the 35% AD treatment in the current app was irrigated on 4 July. Irrigation for the 50% AD treatments in both the modified and current app versions was initiated on 15 and 16 July, respectively. In midseason planted corn, irrigation for the 35% AD treatments in both the modified and current app versions began on 18 July. Irrigation for the 50% AD treatments was initiated on 23 July in the current app and on 27 July in the modified app. Irrigation for the calendar-based plots in late-planted corn began on 4 July.

Early, midseason, and late planted corn experiments received 11.3, 6.8, and 3.8 inches of rainfall before irrigation was initiated, and 2.9, 5.0, and 5.1 inches of rainfall until physiological maturity (R6) growth stage, respectively. The calendar-based irrigation plots had the highest number of irrigation events, the greatest irrigation water applied, and the highest combined irrigation plus rainfall totals (Table 1). Although mid-season planted corn required the most irrigation events and irrigation water, early planted corn received the highest total water (irrigation plus rainfall) due to greater precipitation earlier in the season. In general, 50% AD threshold reduced water use by 80% for the early planting date and 67% for the 16 May planting date. For the 35% AD threshold with the current app settings, water use was reduced by 40%, and for the modified app settings, it was only 20% less than the calendar method (Table 2). Midseason planting date water use reduction was 50% less than the calendar water use for the 35% AD modified and only 33% less for the 35% AD current recommendation.

Table 3 shows yield differences among irrigation treatments. Grain yield did not differ significantly between the 35% AD treatments (current and modified apps) or compared to the calendar schedule. However, the yield penalty for 50% AD threshold indicates that 50% AD threshold may be too high for some growth stages, such as tasseling, or in general, should not be used except in water stress situations. The current app 50% AD threshold resulted in a yield penalty of 19.2 bu./ac, and the 50% AD modified app resulted in a yield penalty of 27.4 bu./ac compared to the calendar method. While the 50% ADs of both apps were not significantly different from each other, they did result in considerable water savings.

Total water use was about 33% less for the 50% AD treatments compared to the calendar method, and the water use for the 35% AD treatments was between 8% to 25% less than the calendar method.

Given that there was no significant yield difference between the modified and current 35% AD recommendation, the new recommendation does not provide a benefit in this study. No difference in the recommendation for 50% AD between current and modified recommendations was found for water or yield differences, but it should only be used in water-limited situations. Additional work is needed to verify these findings, as this was only for one season.

In early planted corn, significantly higher WUE was achieved in the 50% AD plots for both the modified (10.6 bu./ac/in.) and current app–based irrigation schedules (11.1 bu./ac/in.) compared with all other treatments (Table 4). The 35% AD plots using the current app (9.6 bu./ac/in.) were significantly higher WUE than the 35% AD plots using the modified app (8.8 bu./ac/in.) and the calendar-based irrigation treatment (8.3 bu./ac/in.).

In late-planted corn, the results were much more mixed, and it was difficult to draw conclusions about WUE differences from the treatments. The 35% AD modified had the highest WUE (7.9 bu./in.) and the calendar had the lowest WUE (6.4 bu./in.). For the late planting date in June, the lowest WUE in the study was found for the calendar method 5.2 bu./ac/in. likely because of the lower yield that often results from late planting.

Practical Applications

A mobile app used with granular matric potential sensors using either the current or modified soil retention curve and a 35% AD did not have a significant yield difference compared to a weekly calendar irrigation schedule. However, both the modified and current soil retention curves resulted in less water use than the calendar treatment and had a significantly higher water use efficiency for at least one planting date.

For the 50% AD using the current recommendation for the silt loam with pan retention curves, there was a significant yield penalty of 19.2 bu./ac, but reduced water use by 32–33% and significantly improved WUE.

Current recommendations appear sufficient with a more generalized water retention soil data, but a 50% AD may create a yield penalty when used during the entire growing season. Likely, the recommendation should be to use a lower AD during sensitive growth periods, or that a 50% AD is too high for corn in this region. Future work on a consistent AD or growth stage by AD is warranted. Also, developing a soil water retention curve for Calhoun, Memphis, and Calloway silt may be warranted.

Using the current recommendations for the app of 35% AD resulted in no significant difference in yield over a calendar method schedule, but also reduced water use by 33–40%.

Acknowledgments

The authors thank Arkansas corn growers for their financial support of this research through the corn funds administered by the Arkansas Corn and Grain Sorghum Promotion Board. This material is also based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture.

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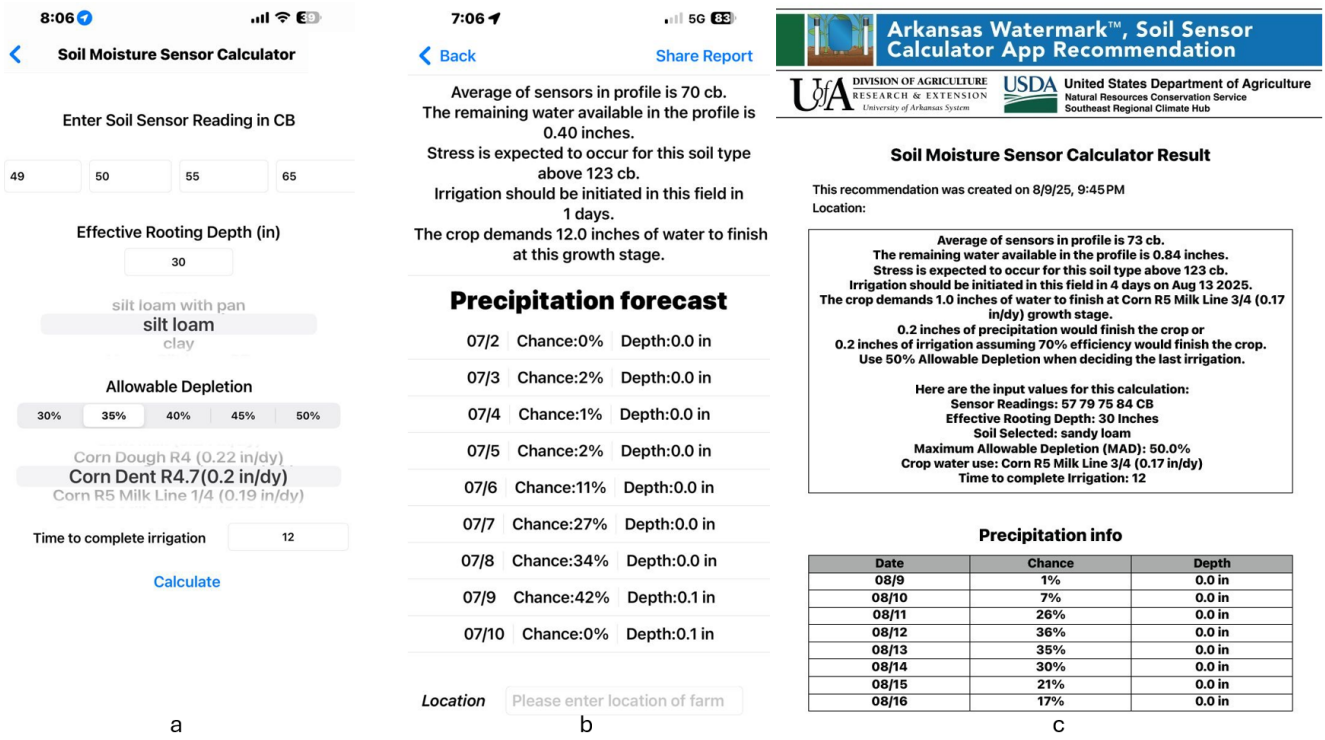


Fig. 1. University of Arkansas Division of Agriculture's Soil Moisture Sensor Calculator App: a-Data entering screen, b-irrigation recommendations in the current app, c- irrigation recommendations in the modified app.

Table 1. Irrigation and rainfall amounts per treatment for early (4/15), midseason (5/16), and late (6/6) planting dates.

	Number of irrigation events			Irrigation water applied			Rain plus irrigation water		
Irrigation treatment	**4/15**	**5/16**	**6/6**	**4/15**	**5/16**	**6/6**	**4/15**	**5/16**	**6/6**
				----------(in.)----------					
Calendar-based irrigation	5	6	5	9.8	11.7	9.9	24.3	23.5	19
50 % AD modified app	1	2		2.0	3.9		16.5	15.7	
50 % AD current app	1	2		2.0	3.9		16.5	15.7	
35 % AD modified app	4	3		7.8	5.9		22.3	17.7	
35% AD current app	1	2		5.9	7.8		20.4	19.6	

Table 2. Total and irrigation water reductions per treatment for early (4/15), midseason (5/16), and late (6/6) planting dates.

	Irrigation water			Rain plus irrigation water		
Irrigation treatment	**4/15**	**5/16**	**6/6**	**4/15**	**5/16**	**6/6**
	----------(in.)----------					
Calendar-based irrigation	9.8	11.7	9.9	24.3	23.5	19
50 % AD modified app	80%	67%		32%	33%	
50 % AD current app	80%	67%		32%	33%	
35 % AD modified app	20%	50%		8%	25%	
35% AD current app	40%	33%		16%	17%	

Table 3. Corn yield per treatment for early (4/15), midseason (5/16), and late (6/6) planting dates.

Irrigation treatment	4/15		5/16		6/6
	----------(bu./ac)----------				
Calendar-based irrigation	202.0	a[†]	149.7	a	96.4
50 % AD modified app	174.6	b	104.9	c	
50 % AD current app	182.8	b	119.2	bc	
35 % AD modified app	196.4	a	137.4	ab	
35 % AD current app	194.8	a	140.9	a	

[†] Different letters within columns indicate a significant difference according to Tukey's honestly significant difference at $\alpha = 0.05$.

Table 4. Water use efficiency (WUE) per treatment for early (4/15), midseason (5/16), and late (6/6) planting dates.

Irrigation treatment	4/15		5/16		6/6
	----------(bu./ac)----------				
Calendar-based irrigation	8.3	c[†]	6.4	c	5.2
50 % AD modified app	10.6	a	6.7	bc	
50 % AD current app	11.1	a	7.6	ab	
35 % AD modified app	8.8	c	7.9	a	
35 % AD current app	9.6	b	7.2	abc	

[†] Different letters within columns indicate a significant difference according to Tukey's honestly significant difference at $\alpha = 0.05$.

Potassium Fertilization Timing Impact on Corn Grain Yield and Individual Yield Components

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Abstract

Effective potassium (K) fertilization is crucial for maximizing corn (*Zea mays* L.) grain yield. We evaluated the impact of K-fertilization timing on corn relative grain yield (RGY) and selected yield components. Trials were established in 2025 at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station (LMCRS), Pine Tree Research Station (PTRS, sites D12 and F6E), and the Northeast Rice Research and Extension Center (NERREC). Fertilizer-K was applied at a rate of 120 lb K_2O/ac targeting preplant, V6, V10, V12, V14, VT, and R2 growth stages, in addition to a no-K control. At maturity, ears from five representative plants of each plot were sampled to measure the number of kernels/row (NKR), number of rows/ear (NRE), and 1000-seed weight (1000-SW), and grain yield was determined using a small plot combine. Soil samples collected preplant categorized soil-test K (STK) as Very Low (LMCRS and NERREC), Low (PTRS-D12), and Medium (PTRS-F6E). Overall, NRE was not affected by fertilizer-K treatments ($P > 0.05$), likely reflecting its strong genetic control in hybrids. At LMCRS, delaying the K application until R1 or R2 significantly ($P = 0.0287$) reduced NKR relative to earlier timings, although partial recovery was observed with applications at R3 and R4. At NERREC, K fertilization significantly ($P \leq 0.05$) increased 1000-SW by 17% compared to the no-K control, while PTRS-D12 showed significant ($P < 0.0001$) increases in 1000-SW despite no significant ($P = 0.8213$) response in RGY. No significant ($P > 0.05$) effect on RGY and yield due to K fertilization timing was observed at PTRS-F6E, which was expected due to the Medium STK and poor pollination observed at this site. These results demonstrate that farmers have flexibility when applying fertilizer-K preplant or in-season, if K deficiency is timely diagnosed with soil or tissue analysis, highlighting the importance of proper management of K to optimize corn yield.

Introduction

Potassium (K) is an essential macronutrient for corn (*Zea mays* L.) production, influencing multiple physiological processes, including enzyme activation, water regulation, and stress tolerance (Marschner, 2022). Given its importance, ensuring adequate K availability throughout the growing season is critical for optimizing yield and yield components, such as the number of kernel rows per ear, the number of kernels per row, and kernel weight. However, unlike nitrogen (N) fertilization, where in-season applications were widely studied (Ruiz Diaz et al., 2013; Slaton et al., 2013), there is limited information regarding the window of opportunity to correct K deficiency in corn.

Corn plants undergo rapid growth and development during early vegetative stages, especially between V5 and V7, a critical period when the number of rows/ear is typically established (Ritchie and Hanway, 1982; Nielsen, 2002; Abendroth, 2011). The kernel number/row is established between V12 and up to VT; while kernel weight is influenced during the grain-filling period, specifically from R1 to R6 growth stages (Ritchie and Hanway, 1982; Nielsen, 2002; Abendroth, 2011). Potassium deficiency during these growth stages can result in poor kernel set, unfilled kernels, and reduced ear weight. Understanding how K fertilization timing influences the formation of these yield components can help identify growth stages beyond which the potential for yield recovery declines or becomes economically unjustifiable.

Traditionally, preplant K fertilization has been the standard practice under the assumption that early-season uptake supports crop demand throughout the growing cycle. While preplant fertilization simplifies management decisions, it may fail to align K supply with crop needs throughout the cropping season. Moreover, a standardized preplant rate may not be ideal for all locations, especially in soils with varying K availability or that are at a greater risk of nutrient loss via leaching or surface runoff (Alfaro et al., 2004; Daniels et al., 2023). Therefore, understanding the dynamics of K uptake, plant K requirement, and individual yield components' response to different K management is key for fine-tuning fertilizer-K rate recommendations and maximizing crop production.

In soybean (*Glycine max* (L.) Merr.), in-season K fertilization is a viable tool to successfully correct K-deficient plants and salvage yield potential (Slaton et al., 2020). Given the high K demand and rapid uptake during early vegetative stages in corn (Bender et al., 2013), along with the timing of yield component establishment (Ritchie and Hanway, 1982; Nielsen, 2002; Abendroth et al., 2011), a similar in-season K fertilization strategy could be beneficial for corn production. Corrective K fertilization during the growing season may help to correct K-deficient corn and sustain yield potential. Hence, this study aimed to evaluate the impact of

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K fertilization timing on corn yield components and identify the window of opportunity to apply K fertilizer and maintain adequate plant development and crop yield potential. Ultimately, we expect that these findings will help farmers make more profitable and efficient K-fertilization decisions.

Procedures

Four corn field trials were established on University of Arkansas Division of Agriculture (UADA) properties in 2025 to evaluate the effect of fertilizer-K application timing on furrow-irrigated corn yield and selected yield components. The locations were the UADA's Lon Mann Cotton Research Station (LMCRS), near Marianna, Ark., the Pine Tree Research Station (PTRS, sites D12 and F6E), near Colt, Ark., and the Northeast Rice Research and Extension Center (NERREC), near Harrisburg, Ark. The previous crop was soybean at all sites. Composite soil samples (6 to 8 individual cores) were collected from the 0- to 6-in. depth from each replicate prior to fertilizer application. Soil samples were dried at 131 °F, passed through a mechanical grinder (Custom Laboratory Equipment Inc., Dynacrush soil crusher model DC-5), and passed through a 2-mm sieve. Soil water pH was measured in a 1:2 soil:water mixture (Sikora and Kissel, 2014), and plant-available nutrients were extracted using the Mehlich-3 extractant (Zhang et al., 2014) with nutrient concentrations of extracts determined using inductively coupled plasma optical emission spectrophotometry (ICP-OES; Spectro Arcos, model 160). Mean soil properties are provided in Table 1.

At each location, fertilizer-K (muriate of potash; 0-0-60) was applied and incorporated at a single rate of 120 lb K_2O/ac at preplant, and surface applied at the V6, V10, V12, V14, VT, and R2 growth stages, in addition to a no-K control treatment. Preplant fertilizer was broadcast onto the soil and incorporated into the raised bed. In-season fertilizer was broadcast on the soil surface and incorporated with irrigation or rainfall within 2 days after application. Due to differences in crop development among sites, the recorded growth stage at fertilizer-K application occasionally differed from the target (e.g., VT ~ R2 or R2 ~ R4). These variations are reflected in Table 2.

Each trial was a randomized complete block with four replicates. Plots were 4 rows wide (38-in. wide raised beds at LMCRS and 30-in. wide raised beds at PTRS and NERREC) and 30-ft long. The corn hybrids planted were Dekalb DKC66-06 at LMCRS-G14H and PTRS-D12 (23 April and 16 May, respectively), Pioneer P1377 at NERREC (15 May), and Pioneer P17677V at PTRS-F6E (17 April), at approximately 35,000 seed/ac. Based on initial soil-test results, trials in 2025 received a blanket phosphorus (P) application of 70 lb P_2O_5/ac as triple superphosphate (0-46-0) at LMCRS and NERREC, and 90 lb P_2O_5/ac at PTRS-D12 and PTRS-F6E. Preplant N was applied at 30 lb N/ac at all locations as urea (46-0-0). After planting, each trial received 200 lb N/ac as NBPT [N-(n-butyl) thiophosphoric triamide]-treated urea at the V8 growth stage and a foliar application of a chelated zinc (Zn) source (1 lb Zn/ac). Irrigation and pest management closely followed the UADA's Cooperative Extension Service (CES) guidelines. Corn was furrow irrigated as needed based on the Arkansas irrigation scheduler set to a 1.5 in. deficit.

At maturity, the ears from five representative plants were sampled from the two middle rows to assess the effect of different K management strategies on selective corn yield components. The number of rows/ear (NRE) and the number of kernels/row (NKR) were determined by direct counting. To estimate the 1000-seed weight (1000-SW, expressed in grams), the kernels from the five ears were combined to form a composite sample, which was weighed, and its moisture content was determined. A subsample of 1000 kernels was then counted using an automatic seed counter (Seedburo, 801-10/B), weighed, and the final weight (g) was adjusted to 15.5% moisture.

The two center rows of each plot were harvested using a small plot combine. Grain weight was adjusted to 15.5% moisture for all trials to determine yield. Relative grain yield (RGY) was calculated by dividing the corn yield of each plot within a site replicate by the maximum yield achieved in each site replicate (the highest mean grain yield for any treatment within each of the four replicates per site) and multiplying by 100 to express values as a percentage (Pearce et al., 2022).

Analysis of variance was performed by location to evaluate the effect of K fertilization timing on corn RGY and individual yield components using the PROC GLIMMIX procedure of SAS v. 9.4 (SAS Institute Inc., 2013) with a gamma distribution and log transformation of data. Replication was set as a random effect and fertilizer-K treatment as a fixed effect, and treatment means were separated using Tukey's honestly significant difference test ($\alpha = 0.05$).

Results and Discussion

The results of the present report focus on corn yield components data, as the impact of K fertilization timing on overall yield (i.e., bu./ac) has been reported (Mengez et al., 2026). Preplant soil-test K (STK) concentrations at LMCRS, NERREC, PTRS-D12, and PTRS-F6E were 58, 30, 82, and 97 ppm K, respectively (Table 1). According to the current CES soil-test guidelines, soil-test K at LMCRS and NERREC were Very Low, while PTRS-D12 and PTRS-F6E were classified as Low and Medium STK, respectively. According to these classifications, a positive effect of K fertilization was expected on corn yield and yield components at LMCRS, NERREC, and PTRS-D12 more than at PTRS-F6E.

Among the evaluated yield components, the NRE was not affected ($P > 0.05$) by treatments (Table 2). This pattern indicates that NRE is primarily associated with hybrid genetics at early corn growth stages (around V5–V7), with limited plasticity thereafter (Ritchie and Hanway, 1982; Abendroth et al., 2011; Nielsen, 2002). A similar lack of responsiveness was observed by Mengez et al. (2025) in the first year of this study, reinforcing the consistency of this trait across environments and growing seasons. However, the NKR showed a significant ($P = 0.0287$; Table 2) response to fertilizer-K application timing at LMCRS. Delaying fertilization until the R1 or R2 stages reduced kernel numbers relative to the other treatments, whereas applications at R3 or R4 maintained kernel numbers comparable to those observed with earlier fertilizer-K application timings. This pattern indicates that kernel retention is particularly sensitive to K

supply near flowering; however, the partial recovery observed with later applications suggests that flexibility is not entirely constrained at that stage. These results highlight the need to align K availability with periods of high crop K demand, especially in soils classified as Very Low in STK, to sustain kernel set and overall yield potential.

Potassium fertilization significantly ($P \leq 0.05$) increased 1000-SW at NERREC and PTRS-D12 (Table 2). At NERREC, K-fertilized treatments averaged 17% greater 1000-SW compared to the no-K control. It is worth highlighting that kernel weight was maximized when K was applied at the R2 growth stage (303 g). Although non-significant ($P = 0.1354$), there was a similar numerical trend for 1000-SW among fertilizer-K timing treatments at the LMCRS location, where the 1000-SW was maximized with fertilizer-K application at the R1 growth stage (323 g), which showed a 18% numerical increase compared to the no-K control. These results align with prior evidence that K is essential for maintaining cellular turgor, activating key metabolic enzymes, and facilitating carbohydrate translocation during grain filling, processes that directly affect kernel density and final seed weight (Marschner, 2022), particularly under the severe K deficiency observed at NERREC and LMCRS. Interestingly, at PTRS-D12, significant differences in 1000-SW were detected ($P < 0.0001$) despite no significant response in RGY ($P = 0.8213$), suggesting that physiological responses to K supply may occur even when yield gains are not observed.

No significant ($P > 0.05$) effect of K fertilization timing on RGY and yield components was observed at PTRS-F6E, as expected given the Medium STK level. Besides the STK category, other environmental factors observed at this location, such as poor pollination, which subsequently results in poor ear development and low kernel set, can also reduce grain yields, highlighting natural variability rather than meaningful treatment effects, as highlighted by Mengez et al. (2026). Overall, these results underscore the variability in corn response to in-season K fertilization across locations and the importance of considering both STK levels and hybrid-specific yield formation dynamics when determining the optimal timing for in-season K applications.

Practical Applications

The 2025 growing season was the second year of this study. Preliminary results show that K fertilization is essential for achieving optimal corn yield, especially in soils with Very Low and Low STK levels, and in-season K applications can effectively mitigate deficiencies when timely diagnosed through preplant soil testing or in-season tissue analysis. Furthermore, the study highlights the importance of aligning soil K availability with corn physiological stages of peak K demand to minimize yield losses from K deficiency and maintain yield potential. Although K fertilization had a significant impact on yield, the response observed was not necessarily attributed to changes in individual yield components. This suggests that yield benefit may result from a combination of effects on kernel number and seed weight rather than a single determining factor.

Additional data will improve our understanding of the interaction between STK levels, tissue-K concentration, and the effect of in-season K applications on corn individual yield components and overall yield response to fertilization. These findings will contribute to fine-tuning K fertilizer recommendations for corn production in Arkansas.

Acknowledgments

Sincere appreciation is extended to the Arkansas Agricultural Experiment Station staff for their continued help and cooperation, without which this project could not have happened. This study was funded by the Arkansas Corn and Grain Sorghum Promotion Board, and the Fertilizer Tonnage Fees administered by the Arkansas Soil Test Review Board and the University of Arkansas Division of Agriculture. This work was supported by the USDA National Institute of Food and Agriculture, Hatch Projects 2800 and 2701.

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Table 1. Mean (*n* = 4) soil chemical properties in the 0- to 6-inch depth for each location and corn K fertilization timing trial, collected prior to initial fertilizer treatments in 2025.

		Mehlich-3 extractable nutrients										
Location[†]	pH	P	K	Ca	Mg	S	Na	Fe	Mn	Zn	Cu	B
		ppm										
LMCRS	6.6	32	58	1005	317	3.5	14	173	193	1.1	0.8	0.4
NERREC	6.3	17	30	772	159	6.6	38	206	49	1.3	0.4	0.4
PTRS-D12	7.6	16	82	2257	295	5.4	23	286	353	1.0	1.1	0.9
PTRS-F6E	7.4	12	97	1380	282	6.2	24	146	426	0.6	0.8	0.2

[†] LMCRS = Lon Mann Cotton Research Station, Marianna, Ark., NERREC = Northeast Rice Research and Extension Center, Harrisburg, Ark., PTRS = Pine Tree Research Station, Colt, Ark.

Table 2. Influence of potassium (K) fertilization timing on mean (*n* = 4) corn relative grain yield and yield components at four different locations in Arkansas during the 2025 growing season.

Fertilizer-K Application Timing[†]	Corn Yield Components and Relative Grain Yield			
	Kernels/Row	Kernel Rows/Ear	1000-Seed Weight	Relative Grain Yield
			(g)	(%)
			----------LMCRS[‡]----------	
No-K Control	39 a[§]	16	273	86 c
Preplant	39 a	16	316	96 a
V6	39 a	16	299	97 a
V10	38 ab	16	306	95 ab
R1	36 b	16	323	90 bc
R2	36 b	16	249	99 a
R3	39 a	16	287	93 ab
R4	40 a	16	277	95 ab
P-value	0.0287	0.6567	0.1354	0.0042
C.V.(%)[¶]	4.8	3.5	7.7	3.6
			----------NERREC----------	
No-K Control	36	16	247 d	52 c
Preplant	37	16	300 ab	95 a
V6	39	16	291 abc	88 ab
V10	41	16	282 bc	83 ab
V12	38	17	282 abc	88 ab
V14	40	17	274 c	79 b
VT	40	16	287 abc	78 b
R2	38	16	303 a	78 b
P-value	0.4532	0.1397	0.0009	0.0002
C.V.(%)[¶]	8.5	3.2	4.4	10.6
			----------PTRS-D12----------	
Control	33	17	280 e	96
Preplant	39	17	320 a	94
V6	38	16	295 dc	95
V10	36	16	322 a	94
V12	36	17	304 bc	96
V14	40	17	283 de	94
VT	39	17	314 ab	92
R3	36	16	285 de	97
P-value	0.0629	0.1640	<0.0001	0.8213
C.V.(%)[¶]	7.8	3.8	3.1	5.4
			----------PTRS-F6E----------	
Control	35	16	270	95
Preplant	35	16	256	90
V6	35	15	236	93
V10	36	16	267	89
V17	37	15	264	92
R1	36	16	269	92
R2	35	16	279	93
R3	35	15	253	92
P-value	0.8349	0.8884	0.3486	0.9808
C.V.(%)[¶]	5.9	4.7	10.3	7.3

[†] Recorded corn growth stage at the time of in-season fertilizer-K application.

[‡] LMCRS = Lon Mann Cotton Research Station, Marianna, Ark, NERREC = Northeast Rice Research and Extension Center, Harrisburg, Ark., PTRS = Pine Tree Research Station, Colt, Ark

[§] Means within a column followed by different lowercase letters are significantly different ($P \leq 0.05$) according to Tukey's honestly significant difference test.

[¶] Coefficient of variation.

Evaluation of Soil Sampling and Tissue Analysis to Modify Corn Nitrogen Management

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Abstract

Corn (*Zea mays* L.) requires significant nitrogen (N) inputs to maximize yield. Additionally, N inputs can provide significant returns on investment, but only if N is managed effectively and not over- or under-applied. Several tools were developed by the University of Arkansas Division of Agriculture (UADA) Soil Fertility Program to refine N management and better predict the yield-maximizing N rate. These tools include a pre-sidedress nitrate test (PSNT) and leaf tissue analysis. To validate the accuracy of these tools for in-season N management, a series of studies was conducted to compare a traditional 2- and 3-way split N application to various programs using the predicted N rates determined via the PSNT and leaf samples. At the UADA Lon Mann Cotton Research Station, N rates were reduced by as much as 80 lb N/ac with no significant reduction in yield. Similarly, at the Northeast Rice Research and Extension Center, season total N rates were reduced by as much as 110 lb N/ac with no yield reduction. These results indicate that both the PSNT and leaf analysis can be used to refine N management in Arkansas irrigated corn production systems without compromising yield.

Introduction

Corn continues to be an important crop in Arkansas production systems. Although acreage fluctuates from year to year, there seems to be a general trend of increasing acreage over time. One of the largest input costs for corn production is fertilization, and nitrogen (N) specifically can account for up to 25% of the total input costs. Previous work has identified that proper rate and timing of N fertilizer application to corn in Arkansas can lead to high N uptake efficiencies (Roberts et al., 2016). In irrigated corn production systems, N uptake values ranged from 50–92% depending on the rate and timing of application. In-season and later application timings tended to result in greater N uptake values.

One advantage Arkansas production systems enjoy is access to aerial application equipment, which allows producers to apply fertilizers to corn much later in the season than could be accomplished with ground equipment alone. Pre-tassel or late-season N applications to corn have become a frequent practice in Arkansas, but previous research has suggested that a wide range in response to these applications can occur.

To better predict the needs for in-season N applications in corn, dos Santos et al. (2021) identified leaf N concentration sufficiency ranges for corn across the V10–VT growth stages. The summary of their results suggested that maintaining a leaf N concentration above 3% for all growth stages from V10–R1 would optimize corn grain yield as influenced by N fertilizer applications.

With the development of leaf N sufficiency ranges for corn production comes the need for validation data that determines whether the predicted rates were adequate to maximize corn grain yield. Proper N management in irrigated corn production systems can be complicated by untimely spring rains and prolonged saturated soils that promote denitrification and loss of plant-available N from the soil system. The ability to apply N in-season all the way until maturity provides producers with the opportunity to monitor their corn crops' N status and ensure the N is not limiting corn grain yield. The research presented here is an attempt to verify that the recently developed tools (PSNT and leaf N concentration) are able to predict N rates that maximize corn grain yield.

Procedures

Corn N management trials were established at the University of Arkansas Division of Agriculture's (UADA) Lon Mann Cotton Research Station (LMCRS) near Mariana, Ark., and the Northeast Rice Research and Extension Center (NERREC) near Harrisburg, Ark., on UADA experiment stations in 2025 to validate the accuracy of in-season tools to adjust N rates for irrigated corn production. The study areas varied for each location but always followed soybean (*Glycine max* L.) in rotation. To compare the efficacy of newly developed tools to standardized N management programs the following treatments were implemented: 1) non-treated control (0 lb N/ac), 2) 2-way split application (30 lb N/ac preplant fb 190 lb N/ac at V6), 3) 3-way split application (30 lb N/ac preplant fb 145 lb N/ac at V6 fb 45 lb N/ac at pretasssel), 4) PSNT only (30 lb N/ac preplant fb PSNT predicted N rate from soil samples taken at V4), 5) V12 leaf only (30 lb N/ac preplant fb predicted N rate from leaf samples taken at V12), 6) V14 leaf only (30 lb N/ac preplant fb predicted N rate from leaf samples taken at V14), 7) PSNT and V12 leaf sample (30 lb N/ac preplant fb PSNT predicted N rate

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from soil samples taken at V4 AND predicted N rate from leaf samples taken at V12), and 8) PSNT and V14 leaf sample (30 lb N/ac fb preplant PSNT predicted N rate from soil samples taken at V4 AND predicted N rate from leaf samples taken at V14). All treatments were arranged in a randomized complete block and replicated four times.

At each location, 60 lb P_2O_5/ac and 90 lb K_2O/ac were applied to ensure that N was the only limiting nutrient. The plots were 4 rows wide (30-in. wide raised beds at NERREC, and 38-in. wide raised beds at LMCRS) and 30 ft long. The corn hybrid P1377VYHR was planted on 15 May, at approximately 35,000 seed/ac at NERREC. The corn hybrid DKC66-06 was planted on 23 April, at approximately 35,000 seed/ac at the LMCRS location. Potassium, phosphorus, and preplant N fertilizers were applied preplant and incorporated into the raised beds. After planting, each trial received either the predetermined N rates at sidedress and pre-tassel or based on either the PSNT or leaf sample results as urea treated with N-(n-butyl) thiophosphoric triamide (NBPT). A foliar application of a chelated zinc (Zn) source (1 lb Zn/ac) was made at the V2 growth stage. Irrigation and pest management were conducted based on current UADA Cooperative Extension Service guidelines, and corn was furrow irrigated as needed based on the Arkansas irrigation scheduler set to a 1.5 in. deficit.

At the V4 growth stage, a 0–12 in soil sample was taken from the center of a middle row within each plot assigned a PSNT treatment. The soil was oven-dried and ground to pass through a 2-mm sieve. Approximately 5 g of soil was added to 50 mL of 2 M KCl and placed on a reciprocating shaker for 30 min. After shaking, the samples were filtered through a Whatman filter paper and analyzed to determine nitrate-N concentration (Mulvaney, 1996). Soil nitrate-N concentration was used to estimate sidedress N fertilizer requirement. At the V12 and V14 growth stage, the whole uppermost collared leaves were collected from five plants in the middle two rows of each plot. Leaf samples were oven-dried at 131 °F until constant weight, ground to pass through a 1-mm sieve, mixed, and total N was determined via combustion (Campbell, 1992). Total N concentrations in the leaf tissue were used to determine in-season N rates. Predicted N fertilizer rates based on the PSNT and leaf samples were applied as soon as possible and incorporated with rainfall or irrigation within 48 hours. At corn maturity, the inside two rows of each plot were harvested and adjusted to 15.5% moisture to determine grain yield. Corn grain yield was analyzed using a one-way analysis of variance to compare the various N management programs for each location. Tukey's Honestly Significant Difference ($\alpha = 0.05$) was used to separate treatments. The statistical analysis was completed using JMP Pro 17.

Results and Discussion

Growing conditions during the spring and early summer of 2025 were consistent with previous years and "typical" for Arkansas irrigated corn production. Although there was a fair amount of rain between preplant N applications at the V4 growth stage, it was most likely not enough to cause substantial N losses via leaching or denitrification. Corn growth was normal through the growing season, and no major pest or environmental issues were encountered.

Corn Grain yield at the LMCRS ranged from 117–231 bu./ac across all treatments. The non-treated control plot yielded 117 bu./ac and suggests a moderate level of native N availability in the soil (Table 1). The highest overall yield of 231 bu./ac was achieved with the V14 leaf sample treatment, but was not different than any other treatment except the non-treated control that received no N fertilizer. The three treatments where PSNT was used predicted sidedress N rates between 110–120 lb N/ac. The narrow range of rates across treatments using the PSNT indicates that there was little to no soil N variability across the plot area at LMCRS. The two treatments that included leaf sampling at the V12 growth stage recommended an application of 30 lb N/ac, but no N was recommended for any of the treatments where leaf samples were collected at the V14 growth stage. Overall, corn grain yields using either a single in-season diagnostic tool or a combination of tools maximized corn grain yield with a season total N rate that was 40- 80 lb N/ac less than the current recommended rate of 220 lb N/ac applied in either the 2- or 3-way split.

Corn grain yield at the NERREC ranged from 181–236 bu./ac across all treatments. The non-treated control plot yielded 181 bu./ac and suggests a high level of native N availability in the soil (Table 2). The highest overall yield of 241 bu./ac was achieved with a 3-way split application program, but was not different than any other treatment except the non-treated control that received no N fertilizer. The three treatments where PSNT was used predicted sidedress N rates between 100–140 lb N/ac. The range of rates across treatments using the PSNT at the NERREC indicates greater soil N variability across the plot area, which coincides with the high level of N availability, as increased native N in the soil often corresponds to greater variability in corn response to N. None of the treatments that included leaf sampling indicated the need for additional N applied in-season above the preplant and sidedress N application rates. Overall, corn grain yields using either a single in-season diagnostic tool or a combination of tools maximized corn grain yield with a season total N rate that was 50–90 lb N/ac less than the current recommended rate of 220 lb N/ac applied in either the 2- or 3-way split.

The initial results of these validation trials indicate that recently developed tools to assist with in-season N management accurately predict N adjustments. Continued refinement of these tools and protocols for their effective implementation should be considered prior to widespread use.

Practical Applications

In times of record-high fertilizer prices and low commodity prices, it is imperative that Arkansas corn producers have ample data to make their N management decisions to maximize yield and profitability. Our data support the use of the PSNT and leaf samples to aid producers in making N management decisions in-season. The further validation and implementation of these tools will allow producers greater flexibility to manage N in their corn production systems. One unique aspect of these tools is their ability to capture soil N availability, which can vary greatly from location to location; potential N losses following preplant N applications; and deficiencies related to other environmental or management decisions. Although there is limited data on

hand, within the next few years, there should be sufficient data to recommend these tools as a standard practice for Arkansas irrigated corn production.

Acknowledgments

Research was funded by the Corn Check-off Program administered by the Arkansas Corn and Grain Sorghum Promotion Board and the University of Arkansas Division of Agriculture.

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Table 1. Nitrogen programs and corn grain yield at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station (LMCRS) during 2025.

Treatment	Preplant	Sidedress	V12	Pretassel	Season Total	Yield
	----------N Rate (lb N/ac)----------					(bu./ac)
Check	0	0	0	0	0	117 b[§]
2-way Split	30	190	0	0	220	230 a
3-way Split	30	145	0	45	220	226 a
PSNT[†]	30	120	0	0	150	225 a
V12 Leaf[‡]	30	120	30	0	180	230 a
V14-VT Leaf	30	120	0	0	150	231 a
PSNT + V12 Leaf	30	110	30	0	170	224 a
PSNT + V14-VT Leaf	30	110	0	0	140	223 a

[†] PSNT = pre-sidedress nitrate test taken from 0–12 inch soil depth at the V4 growth stage.

[‡] Leaf samples were collected from the uppermost collared leaf at the designated sample time or the earleaf once it could be identified.

[§] Corn yields followed by the same letter are not significantly different according to Tukey's honestly significant difference at $P = 0.05$.

Table 2. Nitrogen programs and corn grain yield at the University of Arkansas Division of Agriculture's Northeast Rice Research and Extension Center (NERREC) during 2025.

Treatment	Preplant	Sidedress	V12	Pretassel	Season Total	Yield
	----------N Rate (lb N/ac)----------					(bu./ac)
Check	0	0	0	0	0	181 c[§]
2-way Split	30	190	0	0	220	233 b
3-way Split	30	145	0	45	220	241 a
PSNT[†]	30	125	0	0	155	236 ab
V12 Leaf[‡]	30	120	0	0	150	235 ab
V14-VT Leaf	30	120	0	0	150	233 b
PSNT + V12 Leaf	30	140	0	0	170	230 b
PSNT + V14-VT Leaf	30	100	0	0	130	236 ab

[†] PSNT = pre-sidedress nitrate test taken from the center of the raised bed at 0–12 inch soil depth at the V4 growth stage.

[‡] Leaf samples were collected from the uppermost collared leaf at the designated sample time or the earleaf once it could be identified.

[§] Corn yields followed by the same letter are not significantly different according to Tukey's honestly significant difference at $P = 0.05$.

Impact of Plant Population, Nitrogen Rate, and Hybrid on Irrigated Corn Yield in 2025

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Abstract

Identifying the optimal corn (*Zea mays* L.) plant population and nitrogen rate is critical for achieving high corn yields. Field trials evaluating the impact of corn plant population and nitrogen rate on grain yield were conducted in 2025 at the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Ark.; the Rohwer Research Station near Rohwer, Ark.; and the Jackson County Extension Center near Newport, Ark. Plant populations of approximately 22,000, 27,000, 32000, 37,000, and 42,000 plants/ac were evaluated with nitrogen (N) rates of 0, 150, 200, 250, and 300 lb N/ac. Nitrogen was split-applied at the V1–V2, V4-6, and V10 growth stages. Two commercially grown 115–119-day relative maturity hybrids were planted at each location. At maturity, plots were harvested with a small-plot combine equipped with a weigh system. Corn yield at all locations responded positively to increased plant populations and nitrogen rates, and overall optimal rates were similar across the three locations. At Marianna, depending on the hybrid, corn yield was maximized at 150–200 lb N/ac, and plant populations of 28,990 and 30,190 plants/ac maximized yield. At Rohwer, higher nitrogen rates were needed to maximize corn grain yields than at Marianna, and these were achieved at 300 lb N/ac for both hybrids. Plant populations of 32,000 plants/ac were sufficient to maximize yield. At Newport, with a relatively late planting date of May 23, nitrogen rates of 150 or 200 lb N/ac achieved maximum yields, depending on hybrid, and plant populations of 26,900 or 32,900 plants/ac maximized yields, depending on hybrid.

Introduction

Arkansas average corn yields have steadily increased from approximately 118 bu./ac in 1993 to 182 bu./ac in 2025 (USDA-NASS, 2026), an average increase of nearly 2.1 bu./ac/yr. There are likely several reasons for this increase, but irrigation plays a significant role. In 2025, approximately 92.5% of the corn grown in Arkansas was irrigated (USDA-FSA, 2026), which helps provide consistent yields across years with varying growing-season rainfall and also encourages producers to use more intensive management practices that can lead to higher yields, such as increasing plant populations and applying higher nitrogen rates. Corn plant populations have gradually increased as new hybrids are developed that are better adapted to higher densities, thereby providing higher grain yields. Iowa's average corn plant population increased from 23,500 plants/ac in 1993 to 31,950 plants/ac in 2023 (USDA-NASS 2024b), and Arkansas has seen similar increases. However, USDA-NASS does not survey corn plant populations in Arkansas. Increasing plant populations increases seed cost per acre, and seed cost is now generally the second-highest input cost for corn, behind fertilizer costs (Watkins, 2026). The recommended nitrogen rate for Arkansas-grown, high-yielding irrigated corn is 220 lb N/ac (Kelley, 2025). However, some Arkansas corn growers apply higher nitrogen rates where high yield potential can be achieved.

Arkansas irrigated corn research (Kelley, 2022) has shown that grain yield responds to increasing plant populations, generally up to 30,000 plants/ac, after which yields tend to plateau at plant populations above 30,000 to 35,000 plants/ac. Many producers using high plant populations want to know if higher nitrogen rates are needed to achieve maximum yields. More data are needed to support increasing nitrogen rates as corn plant populations increase. Furthermore, local information on plant population responses for full-season corn hybrids commonly grown in Arkansas is needed to determine whether higher nitrogen rates are required as corn plant populations increase in irrigated fields.

Procedures

Field trials evaluated the effects of corn plant population and nitrogen rate on corn grain yield at three locations in 2025. Locations were the University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station near Marianna, the Rohwer Research Station near Rohwer, and the Jackson County Extension Center near Newport. Plant populations evaluated included 22,000, 27,000, 32,000, 37,000, and 42,000 plants/ac, with 32,000 plants/ac a typical recommended plant population for irrigated corn in Arkansas. Nitrogen rates of 0, 150, 200, 250, and 300 lb N/ac were evaluated, resulting in 25 plant population by nitrogen rate combinations. At each location, two commonly grown hybrids were evaluated. Each treatment was replicated four times within a split-plot design, with nitrogen rate as the main plot and plant population as the subplot. The hybrid was blocked to create side-by-side trials of each hybrid. Plots were four rows wide by 30 feet long, with a 3-foot-wide unplanted alley between replications. Plots were planted with standard commercial vacuum planters on raised beds

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to facilitate furrow irrigation later in the season as needed. Row spacing at Marianna and Rohwer was 38 inches, and at Newport it was 30 inches. Corn hybrids evaluated included Dekalb DKC 68-35 and Innvictis 1993TRE at Rohwer; Dekalb DKC 66-06 and Innvictis 1792TRE at Marianna; and Pioneer 1511YHR and Innvictis 1792TRE at Newport. All hybrids were commercially available with a relative maturity range of 115–119 days.

The soil series and textural classification at Marianna was Memphis/Calloway silt loam, at Rohwer Sharkey/Desha silt loam, and at Newport Dexter silt loam. All sites were conventionally tilled, and the previous crop was irrigated soybean. Planting dates were 17 April at Rohwer, 23 May at Newport, and 16 April at Marianna. All trials were furrow irrigated as needed, following the University of Arkansas Division of Agriculture Cooperative Extension Services (CES) irrigation scheduler program. Production practices for weed and pest control closely followed current CES recommendations.

Pre-plant fertilizers containing potassium, phosphorus, zinc, and sulfur were applied at recommended rates before raised beds were formed and planting began. Nitrogen (N) in urea form was split and applied at 50 lb N/ac at the V1–V2 stage for all treatments except the 0 N rate. Sidedress N was applied at the V4–V6 growth stage and consisted of 50, 100, 150, or 200 lb N/ac for the 150, 200, 250, and 300 lb/ac N treatments. A late-sidedress application of 50 lb/ac N was applied at the V10 growth stage to all treatments except the 0 N plots. A urease inhibitor was not used with any urea fertilizer application due to anticipated rainfall shortly after application.

Soon after emergence, plant populations were counted from the center two rows of each plot to estimate the final plant population (Tables 1–3). Populations varied slightly across locations, with hybrids from the desired populations of 22,000, 27,000, 32,000, 37,000, and 42,000 plants/ac. Heavy rain after planting at Newport resulted in plant stands slightly below desired levels. Before harvest, mature plant height and percent plant lodging were estimated in each plot. Additionally, at Rohwer, ten representative ears from all treatments were hand-harvested from 1 replication to estimate kernels/ear and kernel weight. At each location, at corn maturity, the center two rows of each plot were harvested with a small-plot combine, and yields were adjusted to 15.5% grain moisture. Grain moisture and test weight were recorded for all plots. Grain yield data were subjected to analysis of variance using ARM 2025 (GDM Solutions, Inc., Brookings, S.D.), and means were separated by LSD at $P = 0.05$. Detailed yield component data for kernels/ear and kernel weight (Tables 4 and 5) are from one replication, and only treatment means are presented.

Results and Discussion

Corn grain yield, averaged across hybrid, plant population, and nitrogen rates (excluding the 0 lb N/ac rate), was 204, 221, and 202 bu./ac at Marianna, Rohwer, and Newport, respectively. The 0 N rate yields, averaged across hybrid and plant populations, varied considerably among locations and were 79, 83, and 132 bu./ac at Marianna, Rohwer, and Newport, respectively, indicating significant differences in residual nitrogen among locations, even though all trials followed soybean. Corn yields and plant populations from Marianna, Rohwer, and Newport are presented in Tables 1–3.

At Marianna, depending on the hybrid, averaged across plant populations, a nitrogen rate of 200 lb N/ac was sufficient to achieve maximum yield (Table 1), while higher nitrogen rates provided little additional yield, highlighting the need to match nitrogen rates with expected yields to achieve maximum yield and economic returns. When averaged across nitrogen rates, Dekalb DKC 66-06 and Innvictis 1542TRE yields were maximized by similar populations of 28,990 to 30,190 plants/ac, indicating, much like nitrogen rates, that moderate plant populations were adequate to maximize grain yields, and increasing plant populations did not increase yields even with increasing nitrogen rates. Late-season lodging or greensnap was not observed for any treatments at Marianna. Plant height at Marianna was not influenced by plant population, and only the 0 N rate slightly reduced plant height compared to other nitrogen rates for both hybrids, 89 inches vs 108 inches (data not shown).

Corn yield at Rohwer was the highest of the three locations and was influenced by plant population and nitrogen rate (Table 2). For both DKC 68-35 and Innvictis 1993TRE, yield increased with increasing N rates, with 300 lb N/ac maximizing yield, averaged across plant populations. Grain yield increased with increasing plant populations up to near 32,000 plants/ac, then remained steady for Dekalb DKC 68-35, while yields of Innvictis 1993TRE steadily decreased with increasing plant populations above 32,000 plants/ac. Mature plant height was reduced in the 0 N plots (89 in vs 108 in) for both hybrids and was not influenced by plant population. No late-season lodging or greensnap was observed at Rohwer in any plot.

Corn yield at Newport (Table 3) averaged 202 bu./ac across all plant populations and nitrogen rates (excluding the 0 nitrogen rate) and was positively influenced by nitrogen rate and plant population. Corn grain yield was less responsive to nitrogen than Marianna or Rohwer. When averaged over plant population, corn yield was maximized at 150 lb N/ac for both hybrids, and yield did not increase with increasing N rates. Corn yield increased with increasing plant populations, averaged over nitrogen rates, up to 26,900 plants/ac for Pioneer 1511YHR and between 32,900 plants/ac and 38,290 plants/ac for Innvictis 1792TRE. Overall, corn grain yield was less responsive to nitrogen and plant population, most likely due to high native N levels and a relatively late planting date of 23 May. No greensnap was observed in any plots; however, low levels of late-season lodging were observed prior to harvest. Plant lodging levels were similar for both hybrids and averaged 5% for high population and nitrogen rates, while no lodging was seen in 0 nitrogen plots. Mature plant height was reduced slightly in the 0 N plots (101 in. vs 111–113 in. for higher N rates).

Detailed yield component information, including kernels/ear and kernel weight (grams/200 kernels), was collected at Rohwer (Tables 4 and 5) from 10 consecutive ears per plot within one replication immediately before harvest. Across nitrogen rates, the lowest plant populations had the greatest number of kernels/ear, 626 for DKC 68-35 and 716 for Innvictis 1993TRE, and kernel numbers steadily decreased as plant population increased.

Averaged across plant populations, nitrogen rates of 150, 200, 250, and 300 lb N/ac produced increasing numbers of kernels/ear, with 300 lb N/ac maximizing kernels/ear. Kernel weight was also determined, and a similar trend was observed. Kernel weight in both hybrids was lowest for plants receiving 0 nitrogen (49 or 47 grams/200 kernels) when averaged across plant populations, compared with plots that received 150 lb N/ac or more (60–66 grams/200 kernels), and seed weights increased slightly with nitrogen rates above 150 lb N/ac. Kernels/ear and kernel weight closely follow yield data from Rohwer.

Grain moisture and test weight for Rohwer can be found in Tables 6 and 7. For both Dekalb DKC 68-35 and Innvictis 1993TRE, grain moisture increased with increasing nitrogen rates, averaged across plant populations, and grain from plots with 300 lb N/ac had the highest moisture, while plant population had minimal impact on grain moisture. Test weight was affected similarly to grain moisture, with the lowest test weight observed in plots that received no nitrogen. Plant population had minimal impact on test weight.

Practical Applications

Results from these trials demonstrate that the plant population needed to reach maximum corn yield can vary between hybrid and environment (location) in irrigated corn. Still, current recommended plant populations of 32,000 to 34,000 plants/ac for irrigated fields with adequate yield potential appear appropriate. In these trials, yields were influenced by plant population and nitrogen rate, but plateaued as both increased, indicating that factors beyond nitrogen or plant population were limiting higher yields. For producers considering increasing corn plant populations, adding extra nitrogen beyond a normal nitrogen program does not appear to be needed, even for very high plant populations, and will be an unnecessary production expense.

Acknowledgments

The authors appreciate the support provided by Arkansas corn producers through check-off funds administered by the Arkansas Corn and Grain Sorghum Promotion Board. Support was also provided by the University of Arkansas Division of Agriculture. A special thanks to the Lon Mann Cotton Research Station, the Rohwer Research Station, and the Jackson County Extension Center staff for assisting with this research.

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Table 1. Impact of corn hybrid, plant population, and nitrogen rate on corn yield (bu./ac), University of Arkansas Division of Agriculture's Lon Mann Cotton Research Station, Marianna, 2025.

	Dekalb DKC 66-06						Innvictis 1542TRE						
Plants/ac	0	150	200	250	300	Mean[a]	Plants/ac	0	150	200	250	300	Mean[a]
	----------lb N/ac----------							----------lb N/ac----------					
23,730	78	175	192	195	194	167	21,840	85	158	170	178	191	156
28,990	77	194	209	215	215	182	27,100	85	175	184	207	202	171
33,390	63	191	213	221	228	183	30,160	80	180	205	219	219	181
35,490	81	194	226	218	218	187	33,220	85	183	209	219	221	183
45,880	72	195	226	227	224	189	40,990	87	191	224	236	225	193
$LSD_{0.05}$	----------13.8----------					---	$LSD_{0.05}$	----------14.3----------					---
Mean[b]	74	190	213	215	216	182	Mean[b]	84	177	198	212	212	177

[a] Mean corn yield for each plant population averaged across five nitrogen rates.
[b] Mean corn yield for each nitrogen rate, averaged across five plant populations.

Table 2. Impact of corn hybrid, plant population, and nitrogen rate on corn yield (bu./ac), University of Arkansas Division of Agriculture's Rohwer Research Station, Rohwer, 2025.

	Dekalb DKC 68-35						Innvictis 1997TRE						
Plants/ac	0	150	200	250	300	Mean[a]	Plants/ac	0	150	200	250	300	Mean[a]
	----------lb N/ac----------							----------lb N/ac----------					
21,735	79	176	190	197	200	191	21,940	98	198	211	208	210	185
26,790	65	199	209	215	222	211	27,410	108	203	232	227	235	201
31,540	75	211	225	239	246	230	31,980	95	221	240	251	253	212
36,180	65	209	220	245	246	230	37,865	91	205	233	230	242	200
40,270	65	208	216	238	238	225	41,785	84	191	212	227	244	192
$LSD_{0.05}$	----------19.8----------					---	$LSD_{0.05}$	----------15.4----------					---
Mean[b]	70	211	212	217	230	217	Mean[b]	95	204	226	229	237	198

[a] Mean corn yield for each plant population averaged across five nitrogen rates.
[b] Mean corn yield for each nitrogen rate, averaged across five plant populations.

Table 3. Impact of corn hybrid, plant population, and nitrogen rate on corn yield (bu./ac), University of Arkansas Division of Agriculture's Jackson County Extension Center, Newport, 2025.

	Pioneer 1511YHR						Innvictis 1792TRE						
Plants/ac	0	150	200	250	300	Mean[a]	Plants/ac	0	150	200	250	300	Mean[a]
	----------lb N/ac----------							----------lb N/ac----------					
21,250	113	166	169	178	167	159	22,130	130	173	160	171	168	160
26,960	130	203	200	206	206	189	28,100	143	198	204	198	198	188
31,450	108	200	210	208	214	188	32,900	143	206	206	208	210	195
35,540	120	193	212	218	214	191	38,290	163	218	222	226	225	211
37,680	125	220	221	222	225	203	40,640	146	213	211	212	214	199
$LSD_{0.05}$	----------21.3----------					---	$LSD_{0.05}$	----------22.5----------					---
Mean[b]	119	196	202	206	205	186	Mean[b]	145	202	201	203	203	191

[a] Mean corn yield for each plant population averaged across five nitrogen rates.
[b] Mean corn yield for each nitrogen rate, averaged across five plant populations.

Table 4. Impact of corn hybrid, plant population, and nitrogen rate on corn kernels/ear, University of Arkansas Division of Agriculture's Rohwer Research Station, Rohwer 2025.

	Dekalb DKC 68-35						Innvictis 1993TRE						
Plants/ac	0	150	200	250	300	Mean[a]	Plants/ac	0	150	200	250	300	Mean[a]
	----------lb N/ac----------							----------lb N/ac----------					
21,735	441	677	658	696	660	626	21,940	575	764	752	735	756	716
26,790	407	569	643	643	627	578	27,410	442	621	653	679	680	615
31,540	310	503	503	503	560	476	31,980	457	681	640	621	646	609
36,180	278	480	517	517	534	465	37,865	328	510	588	607	590	525
40,270	311	470	490	490	511	454	41,785	290	537	499	482	516	465
$LSD_{0.05}$			---			---	$LSD_{0.05}$			---			---
Mean[b]	349	540	562	570	578	520	Mean[b]	418	623	626	625	638	586

[a] Mean kernels/ear for each plant population averaged across five nitrogen rates.

[b] Mean kernels/ear for each nitrogen rate, averaged across five plant populations.

Table 5. Impact of corn hybrid, plant population, and nitrogen rate on corn kernel weight (grams/200 kernels), University of Arkansas Division of Agriculture's Rohwer Research Station, Rohwer, 2025.

	Dekalb DKC 68-35						Innvictis 1993TRE						
Plants/ac	0	150	200	250	300	Mean[a]	Plants/ac	0	150	200	250	300	Mean[a]
	----------lb N/ac----------							----------lb N/ac----------					
21,735	51	72	78	79	80	72	21,940	53	69	68	76	75	68
26,790	49	69	77	74	81	70	27,410	45	58	68	67	68	61
31,540	46	66	69	76	75	66	31,980	46	58	63	67	69	61
36,180	48	62	69	73	75	65	37,865	44	57	63	64	63	58
40,270	52	60	65	73	72	64	41,785	47	60	64	69	68	62
$LSD_{0.05}$			---			---	$LSD_{0.05}$			---			---
Mean[b]	49	66	72	75	77	68	Mean[b]	47	60	65	69	69	62

[a] Mean kernel weight for each plant population averaged across five nitrogen rates.

[b] Mean kernel weight for each nitrogen rate, averaged across five plant populations.

Table 6. Impact of corn hybrid, plant population, and nitrogen rate on corn grain moisture (%), University of Arkansas Division of Agriculture's Rohwer Research Station, Rohwer, 2025.

	Dekalb DKC 68-35						Innvictis 1993TRE						
Plants/ac	0	150	200	250	300	Mean[a]	Plants/ac	0	150	200	250	300	Mean[a]
	----------lb N/ac----------							----------lb N/ac----------					
21,735	12.7	13.5	14.2	14.7	14.7	14.0	21,940	13.9	14.0	14.9	15.4	15.9	14.8
26,790	12.5	13.5	13.9	13.9	14.5	13.7	27,410	13.3	13.7	14.3	14.8	15.0	14.2
31,540	12.5	13.6	14.0	13.7	14.2	13.6	31,980	12.5	13.6	14.0	14.2	14.5	13.8
36,180	11.8	13.1	13.4	13.4	13.8	13.1	37,865	12.5	13.3	13.8	14.1	14.1	13.6
40,270	11.7	12.6	13.2	13.5	13.7	12.9	41,785	12.7	13.3	13.8	13.8	14.3	13.6
$LSD_{0.05}$	----------0.6----------					---	$LSD_{0.05}$	----------0.8----------					---
Mean[b]	12.2	13.3	13.7	13.8	14.2	13.5	Mean[b]	13.0	13.6	14.2	14.5	14.8	14.0

[a] Mean kernel weight for each plant population averaged across five nitrogen rates.

[b] Mean kernel weight for each nitrogen rate, averaged across five plant populations.

Table 7. Impact of corn hybrid, plant population, and nitrogen rate on corn grain test weight (lb/bu), University of Arkansas Division of Agriculture's Rohwer Research Station, Rohwer, 2025.

	Dekalb DKC 68-35							Innvictis 1993TRE						
Plants/ac	0	150	200	250	300	Mean[a]	Plants/ac	0	150	200	250	300	Mean[a]
	----------lb N/ac----------							----------lb N/ac----------					
21,735	57.4	59.5	59.9	59.9	60.0	59.3	21,940	57.6	59.1	59.2	59.2	59.1	58.8
26,790	56.2	59.5	60.2	60.2	60.7	59.4	27,410	56.7	59.3	59.9	59.8	59.9	59.1
31,540	56.3	59.3	60.4	60.1	60.3	59.3	31,980	56.8	59.3	59.9	59.8	59.8	59.1
36,180	56.1	58.9	60.1	60.1	60.5	59.1	37,865	56.4	58.9	59.7	60.1	59.8	59.0
40,270	55.2	58.2	59.8	60.3	60.5	58.8	41,785	57.7	59.1	59.6	60.2	60.0	59.3
$LSD_{0.05}$	----------1.0----------					---	$LSD_{0.05}$	----------0.8----------					---
Mean[b]	56.2	59.1	60.1	60.1	60.4	59.2	Mean[b]	57.0	59.1	59.7	59.8	59.7	59.1

[a] Mean kernel weight for each plant population averaged across five nitrogen rates.

[b] Mean kernel weight for each nitrogen rate, averaged across five plant populations.

Refining Recommendations of Corn Hybrid Relative Maturity and Planting Dates in Arkansas

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Abstract

Quantifying the effect of planting date and hybrid relative maturity in Arkansas is crucial for growing high-yielding corn. The effect of planting date and corn relative maturity was evaluated in 2025 at 3 locations in Arkansas. The objective of the study was to quantify the contribution of corn relative maturity, planting date, site, and interaction on variation in yield, number of days to silking, and number of days to maturity. Overall, grain yield ranged from 95 bu./ac to 290 bu./ac. Site location explained 42% of the yield variability, followed by planting date (32%) and hybrid relative maturity (26%). The combination of early planting and full-season hybrids resulted in higher yield compared to late-planted corn. Across all site locations and planting dates, full-season hybrids (>115 days) yielded around 201 bu./ac, compared to 162 bu./ac for short-season hybrids (<100 days), representing a mean yield advantage of 39 bu./ac. Overall, the results indicate that the length of corn vegetative growth stages is primarily controlled by planting date and temperature, while the length of corn reproductive growth stages is primarily controlled by hybrid genetics.

Introduction

Corn production in the mid-South has increased over the past decade. In Arkansas, approximately 810,000 ac. were planted in 2025, which represented a 62% increase compared to 2024, with an average yield of 182 bu./ac (USDA-NASS, 2026). As production increases, planting dates are often delayed due to weather conditions at planting. This raises concern that high temperatures late in the season, during critical growth stages, can negatively affect grain yield. Hybrids with a maturity range of 112 to 120 days, planted in late March or early April, are common in the mid-South (Espinoza and Ross, 2008). While rainfall in the mid-South is usually adequate for corn production without irrigation, adjusting planting dates or hybrid maturity can be used to avoid summer drought and heat stress, and potentially save irrigation water (Edwards et al., 2005).

Early planting is commonly associated with higher yield potential, as corn experiences cooler temperatures during vegetative growth stages and longer days during grain formation (Bruns and Abbas, 2006; Van Roekel and Coulter, 2011). Early plantings in the mid-South provide longer periods for light capture and resource accumulation while decreasing the risk of late heat stress during reproductive periods. However, the cold temperature and high moisture under early planting may affect plant emergence, distribution, and final plant population (Baum et al., 2019). Conversely, delaying corn planting tends to lower yield potential, as crop development is accelerated and the risk of heat and drought stress around flowering increases. The selection of a hybrid's relative maturity affects total corn water consumption throughout the season (Edwards et al., 2005; Williams et al., 2018). Edwards et al. (2005) observed that planting short-season corn hybrids in Arkansas reduced water demand by 30 to 50%, as short-season hybrids had a crop cycle that was 16 to 27 days shorter than that of longer-season hybrids. However, at traditional plant densities (30,000 to 36,000 plants/ac), short-season hybrids yielded on average of 6% less than full-season hybrids while using 30% less water (Edwards et al., 2005). As new hybrids are made available to farmers, there is a need to evaluate corn grain yield for these hybrids at different planting dates and cropping environments across Arkansas.

Procedures

During the 2025 season, 12 commercial hybrids from various seed companies: Pioneer Hi Bred International, Inc. (Johnston, Iowa, USA), Syngenta AG (Basel, Switzerland), DEKALB Genetics Corporation (DeKalb, Ill., USA), Innvictis Seed Solutions (Stuttgart, AR, USA), Gateway Seed Company (Malvern, Ark., USA), and Progeny Ag Products (Batesville, Ark., USA) were evaluated at 3 University of Arkansas Division of Agriculture (UADA) research stations: Lon Mann Cotton Research Station in Marianna (LMCRS), Rohwer Research Station (RRS), and Milo J. Shult Agricultural Research and Extension Center in Fayetteville (SAREC). According to the seed companies, the 12 hybrids ranged in relative maturity from 90 to 120 days. Target planting density was 35,000 seeds/ac across all hybrids and locations. Soil series ranged from Pembroke Silt Loam, Silt Loam, and Herbert Silt Loam for Fayetteville, Marianna, and Rohwer, respectively. Three planting dates were arranged in a strip-plot design with 3 replications per site. Target planting dates were between 25 March and 5 June with 15- to 25-day intervals; however, when

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environmental conditions prevented planting, adjustments were made and reported in Table 1.

The fertilization, irrigation, and management of weeds, insects, and diseases followed the UADA Corn Production recommendations at all locations. Row spacing was 36-in. for the Fayetteville location and 38-in. at the Marianna and Rohwer locations, and plots consisted of four rows measuring 25 ft in length. All vegetative and reproductive phenological stages were tracked from emergence to maturity in Fayetteville. The number of days from planting to silking (R1) was recorded, and the number of days from planting to physiological maturity (R6) was recorded across hybrids and planting dates. Final grain yields were obtained using a plot combine, and grain yield was adjusted to 15.5% grain moisture. The contribution of planting date, hybrid relative maturity, and site to explaining yield variability was quantified using linear models. A two-way Analysis of Variance was conducted to determine whether the duration of developmental stages differed among planting dates and hybrids and their interaction ($P = 0.05$).

Results and Discussion

Grain yields ranged from 95 bu./ac to 290 bu./ac across the entire data set. Location explained 42% of the variability in yield, followed by planting date (32%) and hybrid relative maturity (26%) (Fig. 1). The relatively large contribution of the Location effect reflects characteristics of the site (soil texture, rainfall, temperature) and potential differences in management practices (fertilization timing, irrigation, and pest control). Overall, full-season hybrids yielded better than short-season hybrids across all planting dates and locations (Tables 2, 3, and 4). Across all sites and planting dates, the yield of full-season hybrids averaged 201 bu./ac compared to 162 bu./ac for short-season hybrids, which represents a mean yield advantage of 39 bu./ac. This suggests that even when the planting date is delayed, long-season hybrids outperform short-season hybrids. The magnitude of the advantage of planting full-season hybrids depended on the planting date. Under early planting, full-season hybrids outyielded short-season hybrids by approximately 48 bu./ac. This gap narrowed to around 21 bu./ac under late planting, less than half the early-planting advantage. These findings align with Williams et al. (2018), who described that when planted early, full-season hybrids had more time to express their genetic potential, leading to greater yield gaps between hybrids of different relative maturities.

Clear differences in the number of days required to reach silking (R1) were observed across different relative maturities, planting dates, and their interaction (Tables 5 and 6). The overall ranking of factors explaining time to silking was planting date (74%), followed by hybrid relative maturity (20%), followed by the interaction of both (5%). The combination of short-season hybrids and late plantings decreased the number of days to R1 by up to 15 days compared to full-season hybrids planted early. Greater differences were detected for the number of days from emergence to physiological maturity (R6) across all relative maturities and planting dates (Table 7). The number of days to reach maturity (R6) decreased when short-season hybrids were planted late and increased when full-season hybrids were planted early.

Overall, the shortest hybrid (90-day) reached physiological maturity 21 days before the longest hybrid (120-day) when planted early and 15 days earlier when planted late. Moreover, the difference in crop cycle duration between early- and late-planting hybrids averaged 14 days. Hybrid relative maturity, planting date, and their interaction contributed 45.5%, 43.3%, and 5.5% to the explained variability in days to physiological maturity (Table 8). Although corn relative maturity and planting date interaction was significant, it only explained 5.5% of the variability. The magnitude of the effect of corn relative maturity was larger for days to R6 compared to its effect on days to R1. These findings suggest that the relative maturity of hybrids had a bigger effect on reproductive stages, while planting date had a greater effect on vegetative stages.

Practical Applications

Results from this trial demonstrate insights for hybrid selection and planting date decisions. The strong influence of planting date on the number of days to reach R1 reflects the importance of this management practice as a strategy to minimize the risk of heat stress at around silking, the most critical period for yield determination. These data demonstrate that hybrid relative maturity had a larger contribution during reproductive stages compared to vegetative stages. Full-season hybrids (relative maturity >115 days) outyielded short-season hybrids (relative maturity <100 days) by approximately 48 bu./ac under early planting and 21 bu./ac under late planting. Hybrid selection, therefore, becomes a key management tool to maximize light capture, resource accumulation, and grain yields. The interaction between planting date and relative maturity suggests that hybrid performance depends on the environment in which they grow, and that both management practices need to be considered to maximize yields. Finally, the phenology information shown in this study can serve as a tool to predict phenology stages and know when crops will reach critical developmental stages to schedule key management practices such as fertilization, irrigation, and harvest.

Acknowledgments

The authors appreciate the support provided by the Arkansas Corn and Grain Sorghum Promotion Board. A special thanks to the Marianna Research Station, the Rohwer Research Station, the Milo J. Shult Agricultural Research and Extension Center, and their staff for assisting with this research.

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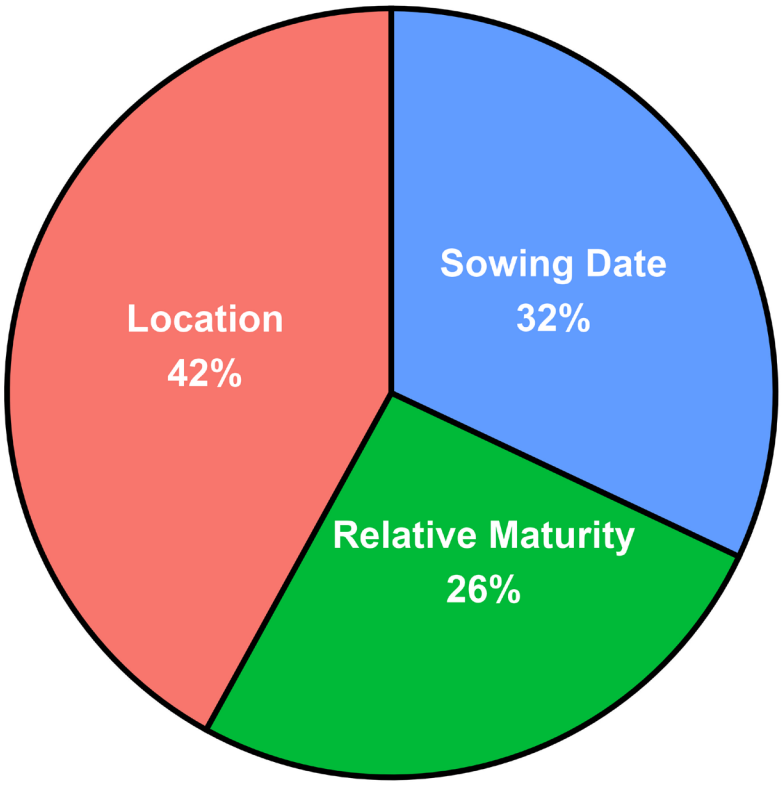


Fig. 1. Yield variability explained by location, planting date, and corn relative maturities in Arkansas during the 2025 growing season.

Table 1. Planting dates for the three Arkansas locations during the 2025 growing season.

Fayetteville	Δ[a]	Marianna	Δ	Rohwer	Δ
11 April (100)[b]		16 April (105)		27 March (85)	
5 May (124)	24	29 April (118)	13	23 April (112)	27
22 May (141)	17	23 May (142)	24	4 June (154)	42

[a] Delta shows the difference in days between planting dates at a specific site.
[b] Numbers in parentheses are Julian dates.

Table 2. Corn yield of hybrids with different relative maturities across planting dates in Fayetteville during the 2025 growing season.

Hybrid	Relative maturity	Yield 11 April planting	Yield 5 May planting	Yield 22 May planting
	(Days)	----------(bu./ac)----------		
NK Brand NK9021-D EZ1	90	144	188	182
Pioneer P96760PCE	96	198	190	208
NK Brand NK0007-AA EZ1	100	178	194	206
NK Brand NK0880-V EZ1	108	194	222	175
NK Brand NK1056-V EZ1	110	221	225	217
Progeny Ag PGY 2010TRE	110	223	234	186
NK Brand NK1307-DV EZ1	113	229	245	217
Pioneer P1511YHR	115	232	247	231
DEKALB DKC 65-99	115	230	235	258
DEKALB DKC 68-35	118	247	250	208
Innvictis A1993T	119	257	281	208
DEKALB DKC 70-45	120	207	248	229

Table 3. Corn yield of hybrids with different relative maturities across planting dates in Marianna during the 2025 growing season.

Hybrid	Relative maturity	Yield 16 April planting	Yield 29 April planting	Yield 23 May planting
	(Days)	----------(bu./ac)----------		
NK Brand NK9021-D EZ1	90	176	143	121
Pioneer P96760PCE	96	195	145	138
NK Brand NK0007-AA EZ1	100	174	156	130
NK Brand NK0880-V EZ1	108	196	151	147
NK Brand NK1056-V EZ1	110	194	146	150
Progeny Ag PGY 2010TRE	110	206	158	124
NK Brand NK1307-DV EZ1	113	192	151	142
Pioneer P1511YHR	115	210	153	135
DEKALB DKC 65-99	115	225	147	150
DEKALB DKC 68-35	118	219	153	157
Innvictis A1993T	119	219	162	153
DEKALB DKC 70-45	120	200	156	160

Table 4. Corn yield of hybrids with different relative maturities across planting dates in Rohwer during the 2025 growing season.

Hybrid	Relative maturity	Yield 27 March planting	Yield 23 April planting	Yield 4 June planting
	(Days)	----------(bu./ac)----------		
NK Brand NK9021-D EZ1	90	--[a]	185	187
Pioneer P96760PCE	96	106	154	113
NK Brand NK0007-AA EZ1	100	160	173	142
NK Brand NK0880-V EZ1	108	198	215	155
NK Brand NK1056-V EZ1	110	192	223	157
Progeny Ag PGY 2010TRE	110	173	194	156
NK Brand NK1307-DV EZ1	113	153	220	115
Pioneer P1511YHR	115	197	222	154
DEKALB DKC 65-99	115	185	229	164
DEKALB DKC 68-35	118	193	233	156
Innvictis A1993T	119	188	237	126
DEKALB DKC 70-45	120	202	230	158

[a] -- indicates a missing value.

Table 5. Days from emergence (VE) to silking (R1) of hybrids with different relative maturities across planting dates in Fayetteville in 2025.

Hybrid	Relative maturity	VE–R1 11 April	VE–R1 5 May	VE–R1 22 May
	----------(Days)----------			
NK Brand NK9021-D EZ1	90	59	52	51
Pioneer P96760PCE	96	59	56	51
NK Brand NK0007-AA EZ1	100	59	56	51
NK Brand NK0880-V EZ1	108	66	56	55
NK Brand NK1056-V EZ1	110	63	56	51
Progeny Ag PGY 2010TRE	110	63	56	55
NK Brand NK1307-DV EZ1	113	66	56	55
Pioneer P1511YHR	115	66	59	55
DEKALB DKC 65-99	115	66	59	55
DEKALB DKC 68-35	118	66	59	55
Innvictis A1993T	119	66	59	55
DEKALB DKC 70-45	120	66	59	55

Table 6. Analysis of variance for days to silking (R1) as affected by corn relative maturity and planting date, and their interaction in Fayetteville in 2025.

Source	Df	Sum Sq	Sum Sq (%)	Mean Sq	F Value	Pr (>F)
Corn Relative Maturity	9	498.7	20	55	111	<0.001
Planting Date	2	1840	74	920	1840	<0.001
Corn Relative Maturity X Planting Date	18	124	5	7	14	<0.001
Residuals	78	39	1.6	0.5		

Table 7. Days from emergence (VE) to physiological maturity (R6) of hybrids with different relative maturities across planting dates in Fayetteville in 2025.

Hybrid	Relative maturity	VE–R6 11 April	VE–R6 5 May	VE–R6 22 May
	----------(Days)----------			
NK Brand NK9021-D EZ1	90	112	102	99
Pioneer P96760PCE	96	112	102	104
NK Brand NK0007-AA EZ1	100	116	102	104
NK Brand NK0880-V EZ1	108	123	114	111
NK Brand NK1056-V EZ1	110	123	114	111
Progeny Ag PGY 2010TRE	110	123	114	107
NK Brand NK1307-DV EZ1	113	123	114	111
Pioneer P1511YHR	115	123	114	111
DEKALB DKC 65-99	115	125	126	114
DEKALB DKC 68-35	118	133	122	111
Innvictis A1993T	119	133	122	114
DEKALB DKC 70-45	120	133	126	114

Table 8. Analysis of variance for days to maturity (R6) as affected by corn relative maturity and planting date, and their interaction in Fayetteville in 2025.

Source	Df	Sum Sq	Sum Sq (%)	Mean Sq	F Value	Pr (>F)
Corn Relative Maturity	9	4327	50	481	144	<0.001
Planting Date	2	3616	42	1809	543	<0.001
Corn Relative Maturity X Planting Date	18	481	5.5	27	8	<0.001
Residuals	78	260	3	3.3		

Development and Verification of a Stand Counting Application Using Drone Imagery for Research and Production Decision Support

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Abstract

Stand counts and plant population estimates are valuable production metrics, but often not quantified because they are time-consuming to collect. A custom You Only Look Once Version 8 (YOLOv8) object detection algorithm was trained to detect and quantify early vegetative corn plants. This object detection model was embedded in a simple-to-use Python interface. A workflow was evaluated that combined this software with accessible drone-based data collection. Imagery was collected from the drone at 10 ft altitude between V1 and V3 growth stages to obtain very high-resolution imagery. Imagery was processed through the software to get stand counts, an interactive map that shows population variations across a field or study area, and an Excel file with raw and processed data summaries. Field testing of this workflow yielded a precision value of 0.9830 and a recall value of 0.9347, strongly suggesting that outputs of this workflow are highly accurate and can be used in production decisions where population numbers are valuable.

Introduction

Optimal plant populations heavily influence yield and profitability; however, establishing robust plant population estimates at scale to inform replant or other production decisions is cumbersome and time-consuming. A user-friendly and robust counting tool that leverages the automated data collection capabilities of drones could significantly facilitate these estimates. Furthermore, if population data is incorporated into machine-readable maps, population estimates could inform early replant decisions, or site-specific applications of nutrients with Variable Rate Technology (VRT). A prerequisite of this, however, would be the automation of population estimates across whole fields. This project will have the initial value of building a stand-counting tool for traditional production decisions and potentially be used as the foundation for a variable-rate map generator for site-specific decisions and potential applications.

Procedures

A DJI Mavic 3 enterprise was used, which has a permanently fixed RGB 4/3 CMOS, 20MP sensor with a mechanical shutter. While this is considered a commercial drone, it was chosen for its relatively accessible base cost, of less than $4,000, with fully autonomous mapping mission capabilities. This platform and camera were used to collect both training and verification data. The described workflow should work with any of the DJI Mavic 3 enterprise series, including the base enterprise, thermal, and multispectral models.

Imagery was collected on two plant population study sites over two years, where strips of varying seeding rates were established. These 100 plots were established in 2024 and again in 2025 at both the University of Arkansas Division of Agriculture's Jackson County Extension Center (35.5715763 °N, 91.2539575 °W) located near Newport, Arkansas and the Lon Mann Cotton Research Station (34.734886 °N, 90.764146 °W) located near Marianna, Ark. Waypoint flight missions were used where the collection points were in the center of each plot and at an altitude of 10 ft. Images were captured with the camera at an angle aiming straight down and capturing 14 ft long (row length) and 10 ft wide, ensuring that at 4–14 ft long rows were imaged in each plot, regardless of bed spacing (Newport and Marianna sites were planted on 30 and 38 in beds, respectively). Imagery was collected within a week after corn emergence.

Training and validation data were created by manually drawing bounding boxes around each corn plant in plot imagery using a draw polygon tool in ArcGIS Pro. The labeled plot data were used in a custom Python script to train a YOLOv8 convolutional neural network. This is a process known as transfer learning, where a sophisticated object detection model that is published open source, like YOLOv8, is customized on a much narrower data set. The result is a sophisticated model that is very specialized, in this case, looking exclusively for early vegetative corn plants (V1–V4 stage).

The software being evaluated is written in Python (Python 3.10.4) and delivered as an executable file that can be installed on Windows PCs. Upon launching a simple user interface, it initially asks if the user needs to build a flight plan or analyze imagery from a previous mission. If a “Generate flight plan” is selected, the user is asked for a field boundary in the form of a shape file, and a waypoint mission is built that, when loaded onto a compatible drone, properly collects field imagery optimized for the analysis workflow. If “Analyze imagery” is selected, the user interface asks for a project name, the row spacing of the crop, and the number of rows captured in a single

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image, and then allows the user to browse for their imagery folder. Once imagery is loaded and the user starts processing, this program walks through eight steps.

1. Creates a processed imagery folder and a formatted Excel file.
2. Extracts the geolocation information from the images for later plotting.
3. Uses the trained model to label corn plants in the image.
4. Uses the user input information to convert raw count to estimated plants per acre.
5. Writes the count and acre estimate to the Excel file with location information.
6. Saves the labeled image to the processed imagery folder.
7. Uses the Excel file to plot the location and estimated plants per acre for each image (Fig. 1).
8. Starts an interactive user interface that is clickable and zoomable for field truthing, where high-resolution annotated photos (Fig. 2) can be accessed by clicking on the plotted points.

For model evaluation, a subsample of manually labeled imagery was withheld for model validation that included 100 plot photos with a total of 11,253 plants. Detections were made on validation imagery from plant population trials using a custom Python (Python 3.10.4) script with the corn detection YOLOv8 model. Outputs or "predictions" of this script were shapefiles containing bounding box detections in each image referenced to the pixel space of the image. A separate "ground truth" shapefile was manually created for each photo where plants were labeled with similar bounding boxes in the same image pixel space reference system. For each plot image, the "ground truth" shapefiles were compared with the "prediction" shapefiles using the "Compute Accuracy for Object Detection" tool found in ArcGIS Pro version 3.1.2 (Esri, Redlands, CA). The Intersection Over Union (IOU) parameter was set to 0.50, meaning that to be considered a true detection, the boxes must have >50% overlap between the union of both the detection box and the ground truth box. Output evaluation metrics for this tool were model precision and model recall. Model precision is the ratio of the accurate plant count to the number of guesses made by the model, mathematically calculated using Equation 1.

$$Precision = \frac{Correct\ Detections}{(Correct\ Detections + Wrong\ Guesses)} \quad \text{Eq. (1)}$$

Model recall is the ratio of the model's accurate predictions to the total number of plants, mathematically calculated using Equation 2.

$$Recall = \frac{Correct\ Detections}{(Correct\ Detections + Misses)} \quad \text{Eq. (2)}$$

Results and Discussion

Model precision as evaluated by Equation 1 was calculated to be 0.9830 (Fig. 3). As a ratio of the accurate plant count to the number of guesses made by the model, this metric speaks to how accurate model predictions are when they are made. Another way of saying this is that when a model makes a prediction, it is 98.30% accurate. This metric should build trust in the results because it means that the model outputs will have very few false positives.

Model recall, as evaluated using Equation 2, was calculated to be 0.9347 (Fig. 3). As a ratio of model accurate predictions to the total number of plants, this metric speaks to how good a job the model does at detecting all the plants. Another way of saying this is that the model detects 93.47% of the plants of interest.

The custom model performed well as measured by output precision and recall; however, further testing is warranted to determine the model's ability to generalize in differing soil textures or moisture content, or varying degrees of weed pressure. It additionally should be noted that this evaluation was conducted on imagery when plants were approximately 7–10 days post-emergence. As plants mature and overlap, count accuracy is expected to degrade significantly.

Practical Applications

Automating plant population estimates within research programs can save a significant amount of time and labor while increasing the overall accuracy of raw counts and plant per acre estimates. Automating the same estimates in production field facilities with quick and easy decisions about replants, fertilizer rates, and expected yields that are traditionally not feasible. This accurate software tool makes it easy to construct intelligent flight plans, automate data collection, perform simple analysis, and output an interactive map along with an easy-to-manipulate Excel file. The combination of sophisticated hardware, software, and artificial intelligence presented in an easy input, easy output workflow has great utility that can easily be adopted, used, and directly informs strategic production decisions.

Acknowledgments

The authors appreciate the support provided by Arkansas corn producers through the Arkansas Corn and Grain Sorghum Board. Support was also provided by the University of Arkansas Division of Agriculture.

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Fig. 1. Georeferenced plant population estimates plotted on an interactive map. Counts were taken at Newport with populations at V1-V2 and Marianna with populations at V2-V3 (Marianna shown). Users can zoom into and click to open the annotated counts for truthing.



Fig. 2. An example pop-up from a user click, showing an annotated image. This inspection can be used to find errors in the data before production decisions are made.

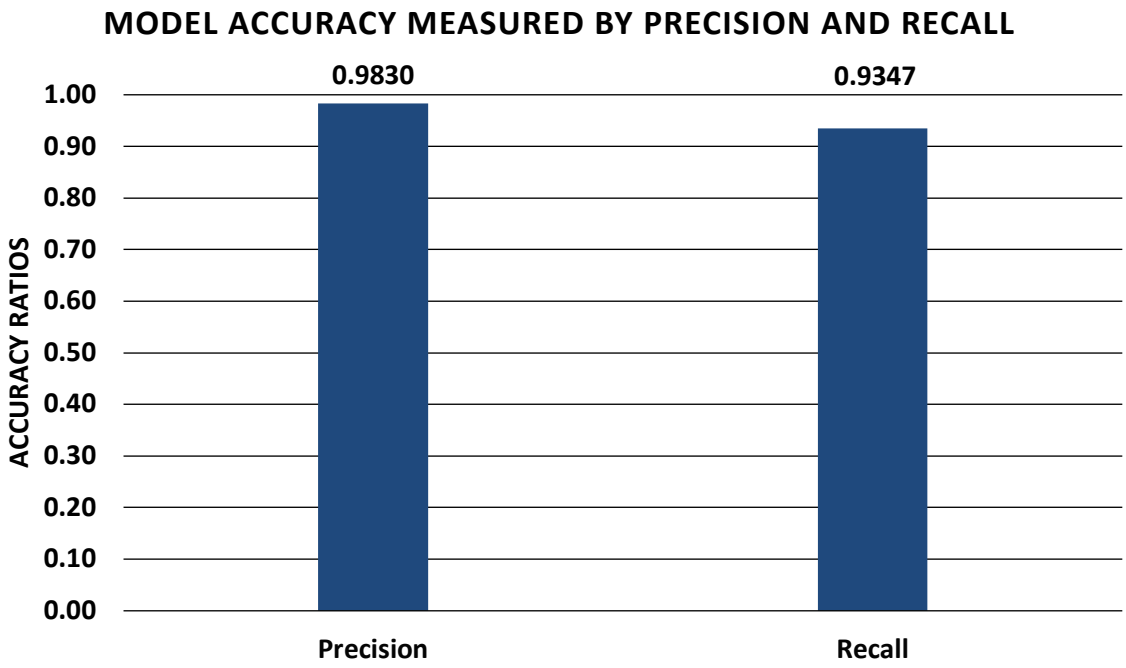


Fig. 3. Precision and recall ratios from field trials. Both metrics suggest that the model is highly accurate and is usable in production systems.

Soil Respiration over Time in Furrow-Irrigated Corn With and Without Cover Crop in the Lower Mississippi River Basin

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Abstract

The pattern of carbon dioxide (CO_2) release over time from the soil at the field scale is not completely understood. The objective of this study was to evaluate CO_2-flux trends from furrow-irrigated corn (*Zea mays* L.) with and without a cover crop (i.e., CC and No-CC, respectively) over the course of the 2024 growing season in the Lower Mississippi River Basin. Carbon dioxide fluxes were measured from 5 May to 18 August 2024, four times a day (i.e., 0300, 0900, 1500, and 2100 hours) from each of the two CC treatments. Linear trends were significant, but were only able to explain 3% and 10% of the CO_2-flux variability for CC and No-CC treatments, respectively. The current study provides preliminary insights to improve the understanding of greenhouse gas production and release from upland, furrow-irrigated corn production.

Introduction

Evaluation of greenhouse gas (GHG) emissions from the soil is complicated by the effects that soil physical (i.e., porosity, texture, and structure) and chemical-biological (i.e., organic matter content and microbial abundance and composition) properties can have on GHG production and release (Smith et al., 2018). Among the three main GHGs [i.e., carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)] produced and emitted from agricultural production systems, CO_2 has the greatest magnitude and has relatively more stable and predictable temporal patterns compared to the more sporadic nature of CH_4 and N_2O (Luo et al., 2015; Jung et al., 2010; Zhou et al., 2009). The magnitude and variability of CO_2 fluxes among ecosystems and over time often make the assessment of soil CO_2 fluxes difficult and challenging to explain (Bond-Lamberti et al., 2019).

Analysis of GHG patterns over time, particularly CO_2, can provide important information on where and when over- or underestimations occur (Wood et al., 2013). To enhance the accuracy of mathematical models to predict and explain the behavior of GHGs from the soil, it is necessary to evaluate the structure of the raw data collected from the field (Bauser et al., 2020). An underused approach to determine the variability of GHG-flux data over time and help address the underlying structure of GHG data is time-series analysis.

Although limited, soil-surface CO_2 flux studies in the Lower Mississippi River Basin (LMRB) have been conducted in a variety of ecosystems and under different management practices to assess how the soil, biosphere, and atmosphere interact with respect to CO_2 production and release from the soil to the atmosphere (Fong et al., 2020; Brye et al., 2016; Helton et al., 2015; Brye and Riley, 2009; Brye et al., 2006). However, to date, no agroecosystem studies in the LMRB have assessed GHGs through time-series analysis of high-density, CO_2-flux data. Therefore, the objective of this study was to use time-series analysis to assess soil-surface CO_2 fluxes from a furrow-irrigated, corn (*Zea mays* L.) production system with and without a cover crop (i.e., CC and No-CC, respectively) over the 2024 growing season in the LMRB. It was hypothesized that linear trends and multiple, repetitive patterns (i.e., cycles) would be statistically identified during the growing season in both CC treatments due to fluctuations of day- and nighttime environmental field conditions.

Procedures

A 160-ac (64-ha) field was divided into strips parallel with the predominant 0.2% slope and included several raised beds. Each strip was characterized by a specific CC treatment. Two adjacent strips were selected within the field for the current study. The current study's area comprised four plots, each composed of two raised beds, in two different, adjacent cover crop (CC) treatments: a CC [i.e., a mix of cover crops, composed of 69% cereal rye (*Secale cereale*), 16% crimson clover (*Trifolium incarnatum*), 7% balansa clover (*Trifolium michelianum*), and 8% radish (*Raphanus sativus*)] and a No-CC treatment, resulting in two replicates per CC treatment. Fertilizer, pesticide, and herbicide application rates and timings were the same under both CC treatments. The management history of the study area, along with field operations, irrigation, fertilizer, herbicide, and pesticide applications was previously described by Della Lunga et al. (2025).

Greenhouse gas concentrations were measured from 5 May to 18 August 2024, four times a day at regular and equally spaced intervals (i.e., 6-hour intervals) at 0300, 0900, 1500, and 2100 hours from each of the four plots, for a total of 420 observations per plot over the course of the complete 2024 corn growing season. The complete configuration, assembly, and settings for gas measurement, analysis, and flux calculations were previously described by Della Lunga et al. (2025).

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Time-series analysis was conducted in JMP (v. 17.1.0, SAS Institute, Inc., Cary, N.C.) using hourly CO_2 fluxes over time from the CC and No-CC treatments, which were analyzed separately. A decomposition process was used to determine whether a significant linear trend over time existed in both CC treatments. Based on autocorrelation and partial autocorrelation functions (i.e., ACF and PACF, respectively), a decomposition process to remove a repetitive cycle composed of a specific number of units (i.e., lags) was used on the de-trended time series for both CC treatments. Significance was judged at the 0.05 level.

Results and Discussion

Carbon dioxide fluxes over the course of the growing season showed nearly identical temporal trends from the two CC treatments, although visually, sporadic and wider fluctuations occurred from the CC treatment compared to the No-CC treatment (Fig. 1). The CO_2 fluxes over time in both CC treatments clearly depicted the often-described sawtooth pattern associated with plant growth and decomposition (Xu et al., 2023; Fig. 1).

Averaged over time, CO_2 fluxes from CC and No-CC averaged 0.54 and 0.48 g m^{-2} h^{-1}, respectively, suggesting that soil respiration can be increased when plant residues are added to the soil surface via CC use (Della Lunga et al., 2025). Visual assessment of CO_2 fluxes from both CC treatments suggested the lack of a clear trend over time, but strongly indicated the presence of repetitive patterns along with random noise (Fig. 1).

Spikes at regular intervals of four lags were visible for both CC treatments in the ACF and PACF results, suggesting seasonality in the data (Fig. 2; Davey and Flores, 1993). The ACF coefficients from CC differed ($P < 0.05$) from zero at every lag multiple of 4, up to lag 24 (Fig. 2). In contrast, the PACF coefficients from CC differed ($P < 0.05$) from zero only at lag 4, 12, 16, and 24 (Fig. 2). From the No-CC treatment, ACF coefficients differed from zero for lag 1 to 4 and at every lag multiple of 4, up to lag 24, while PACF coefficients differed ($P < 0.05$) from zero at lags 1, 3, 4, 8, 12, 16, and 20 (Fig. 2). The regular spikes in the ACF and PACF results indicated that past CO_2 fluxes had a strong predictive power for the subsequent, future CO_2 fluxes (Fig. 2; Box and Pierce, 1970). Significant autocorrelation between GHG emissions datasets, identified through ACF and PACF analyses, was reported in a meta-analysis of GHGs across European countries using data from 1990 to 2022 (Barbulesco, 2025). Correcting a time-series analysis, especially when the sample size is relatively small, for autocorrelation has been shown to limit type I error inflation and reduce under- and/or overestimation of the models' errors (Bence, 1995).

The decomposition process demonstrated that a significant ($P < 0.05$) trend was part of the CO_2 flux pattern over time in both CC treatments (Table 1). The negative trend (i.e., decreasing CO_2 fluxes over time) identified in the time series from both CC treatments was likely driven by lower root respiration rates after plant maturity was reached. Similar results were reported in previous studies in irrigated corn trials, where the soil respiration rate decreased during the grain-filling stage when irrigation was terminated to prepare the field for harvest (Table 1; Zhang et al., 2019; Brye et al., 2016).

An additional decomposition process was conducted on the time series of both CC treatments after the linear trend was removed. The ACF and PACF significantly indicated the presence of repetitive patterns every 4 lags (Fig. 2). Therefore, the de-cycling step was analyzed with 4 units in each cycle for both CC time series (Table 2). The amplitude of the cycle from CC was 25% numerically greater than from No-CC, while the phase of the cycles from both CC treatments was similar, suggesting stronger repetitive fluctuations of CO_2 fluxes from CC than from No-CC (Table 2; Stolwijk et al., 1999).

The phase of the repetitive patterns in the two time series indicated that the beginning of the waves in both time series did not start with the first measurement, but was shifted 0.49 units earlier in time (Table 2; Deng and Fu, 2019). The consistently repetitive, 4-unit cycles observed in the time series from both CC treatments were likely related to day- and night-time variations in soil and air temperatures that controlled CO_2 fluxes (Table 2). The evaluation of repetitive patterns in the time series for both CC treatments indicated that similar physical, chemical, or biological processes were acting on both CC treatments during the entire growing season, consequently impacting soil respiration similarly under CC and No-CC.

Practical Applications

Results of the current study indicated that the time of the day when CO_2 concentration changes over time is measured can impact the magnitude of the CO_2 flux (Table 2). Air-temperature corrections on gas-flux calculations have been suggested in situations where GHG measurements occurred outside the temporal window when the air temperature was greater or lower than the daily temperature average (IPCC, 2021). Sampling protocols have been developed and evaluated for GHG analysis using various closed-chamber methods by agencies and organizations, such as the Food and Agriculture Organization (FAO) of the United Nations and the International Atomic Energy Agency (IAEA), although budgetary and/or logistic considerations can dictate how frequent and during what window of time GHG sampling can occur in a study area (Sander and Wassmann, 2014).

Knowledge of the daily cycles of soil respiration can represent an alternative, yet accurate way to contextualize CO_2 fluxes measured at different daily times during the period of study (Table 2). Time-series analyses of CO_2 fluxes from agricultural fields provide useful information to guide research toward the most appropriate measurement protocols and statistical tools to reliably assess treatment differences and modeling approaches. Future studies should evaluate the structure of long-term time series data for additional GHGs, such as CH_4 and N_2O, from corn and other upland, furrow-irrigated, row-crop systems to develop guiding protocols that allow for improved understanding of the complex nature of GHG production and release from the soil to the atmosphere.

Acknowledgements

Support was provided by the Arkansas corn and grain sorghum producers through check-off funds administered

by the Arkansas Corn and Grain Sorghum Promotion Board. This research was supported by the University of Arkansas Division of Agriculture. This material is based upon work that was supported, in part, by the U.S. Department of Agriculture Partnerships for Climate-Smart Commodities, award number NR233A750004G041. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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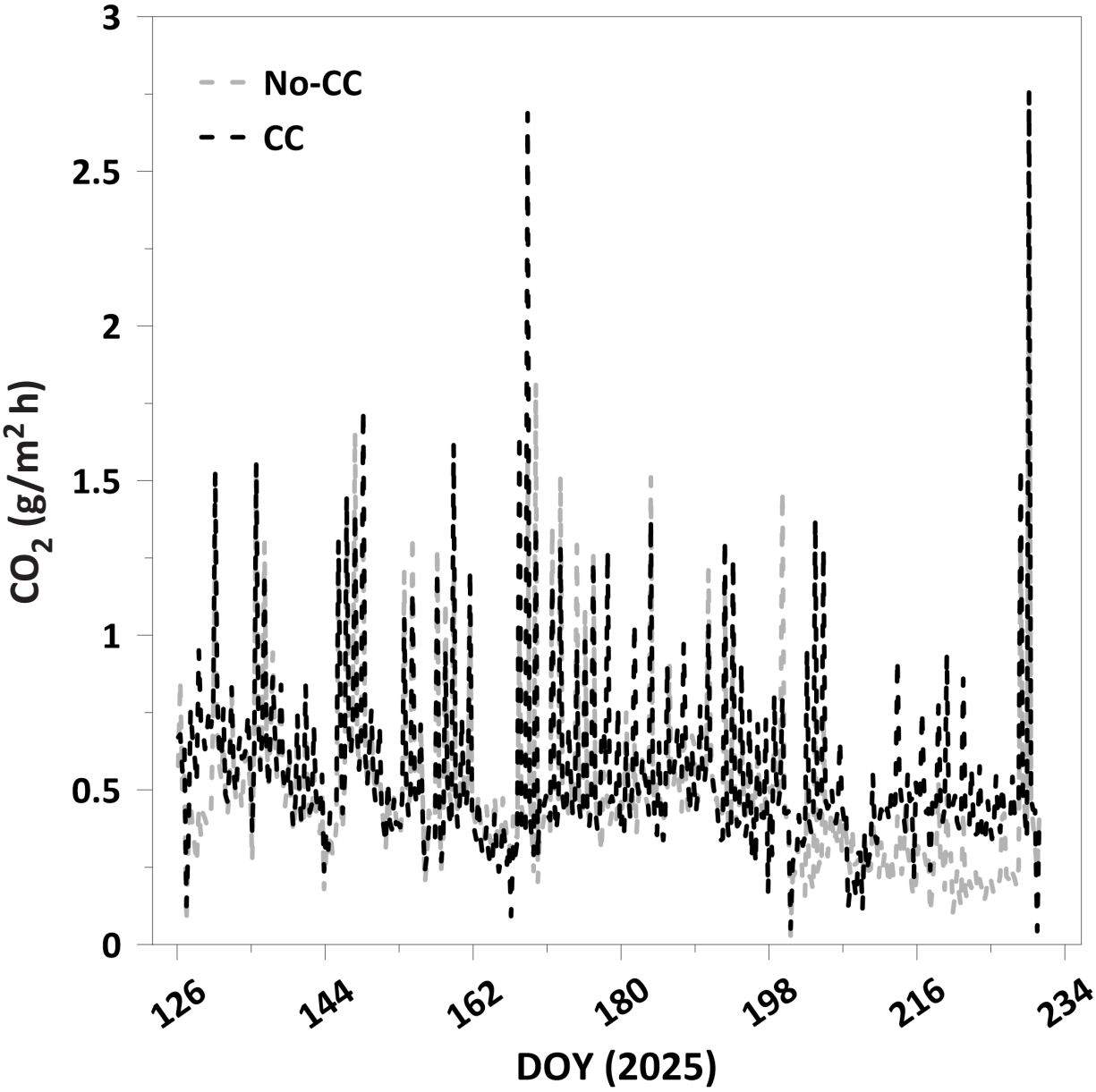


Fig. 1. Carbon dioxide (CO_2) fluxes measured at four specific hours (i.e., 0300, 0900, 1500, and 2100 hours) each day (i.e., day of the year, DOY) from furrow-irrigated corn with cover crop (CC) and without cover crop (No-CC) during the 2024 growing season at the Vayda Regenerative Farm near Clarksdale, Miss.

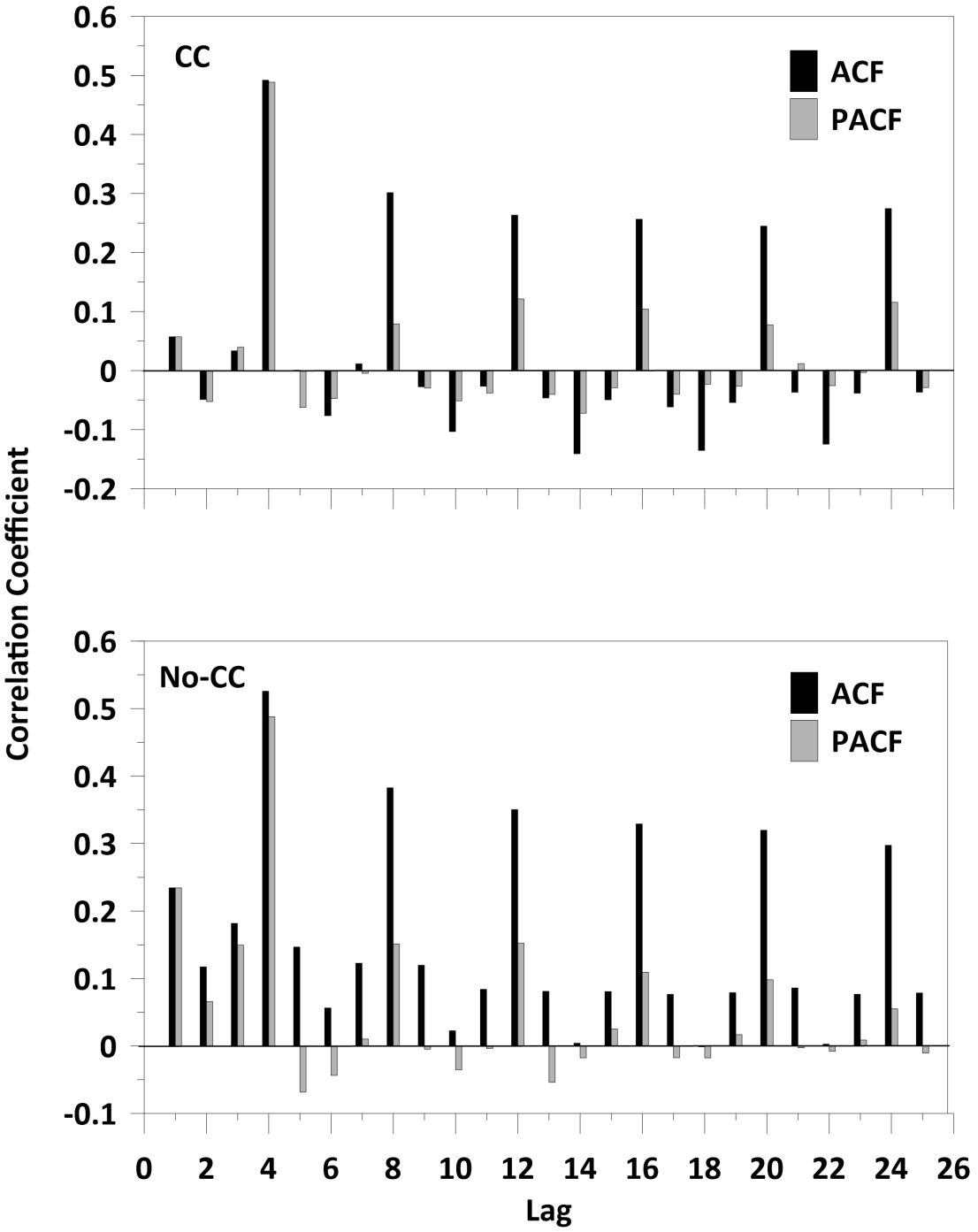


Fig. 2. Graphical representation of the autocorrelation and partial autocorrelation functions (ACF and PACF, respectively) for time series of carbon dioxide (CO_2) fluxes over time in the first 25 lags from furrow-irrigated corn with cover crop (CC) and without cover crop (No-CC) during the 2024 growing season at the Vayda Regenerative Farm near Clarksdale, Miss.

Table 1. Summary of simple linear regression analyses to predict carbon dioxide (CO_2; n = 420) fluxes (g/m^2 h) from furrow-irrigated corn with cover crop (CC) and without cover crop (No-CC) for the 2024 growing season at the Vayda Regenerative Farm near Clarksdale, Miss.

Response variable	Treatment	Model parameter	Coefficient (Standard error)	Overall model *P*-value	Overall Model R^2	RMSE[a]
CO_2	CC	Time	-0.002 (0.0005)	<0.001	0.03	0.301
	No-CC	Time	-0.003 (0.0004)	<0.001	0.10	0.271

[a] RMSE = root mean square error.

Table 2. Summary of cycle patterns determined for carbon dioxide (CO_2; n = 420) fluxes (g/m^2 h) after trend removal from the time series for furrow-irrigated corn with cover crop (CC) and without cover crop (No-CC) for the 2024 growing season at the Vayda Regenerative Farm near Clarksdale, Miss.

Parameter	CC	No-CC
Amplitude	0.20	0.16
Units per cycle	4	4
Phase	0.49	0.49
Constant	0	0
Formula	$0.20*\cos^a(2*\pi^a*((1/4)*t^a + 0.49))$	$0.16*\cos(2*\pi*((1/4)*t + 0.49))$

[a] cos = cosine; π = pi; and t = time in hours.

Sustainable Wax Recovery from Bioethanol Residues: Supercritical Carbon Dioxide Fractionation of Grain Sorghum Side Streams

A. Tuhanioglu,[1] N. Pinar Camur,[1] and A. Ubeyitogullari[1,2]

Abstract

This study characterizes lipid fractions obtained from post-fermentation bioethanol lipid slurries (LS) derived from different batches, with an emphasis on carotenoid behavior, wax recovery via supercritical carbon dioxide (SC-CO_2) fractionation, and lipid class distribution. Three LS batches with different corn (C)/sorghum (S) ratios (i.e., C60-S40, C50-S50, and C40-S60) were analyzed. SC-CO_2 fractionation (167 °F, 5800 psi, 6 h) yielded a carnauba-like wax from corn-heavy LS (C60-S40) with a sharp melting peak at 180 °F. Batches enriched with sorghum (C50-S50 and C40-S60) showed distinct bimodal transitions at approximately 133 °F and 165 °F, suggesting the presence of more complex, multi-phase wax structures. Natural lipids (triacylglycerols, diglycerols, waxes, and hydrocarbons) accounted for >90% of total lipid mass across all samples. Polar lipids were present in small amounts, with glycolipids comprising ~3.5% (w/w), while phospholipids accounted for less than 1% (w/w). The dominant carotenoid types in C60-S40, C50-S50, and C40-S60 were beta-carotene (152.3 ± 5.6 ppm), lutein (157.3 ± 8.0 ppm), and zeaxanthin (80.4 ± 1.5 ppm), respectively. The protein (<0.5%) and ash (~0.02%) contents of all LS batches were negligible. These findings highlight the compositional and processing complexities introduced by sorghum in LS systems and underscore its potential in the development of functional wax and lipid products.

Introduction

In recent years, biorefineries have attracted considerable global attention as a sustainable alternative to traditional fuel production (Aragonés et al., 2022; Rusu et al., 2020). These facilities effectively combine the production of value-added products and energy by utilizing biomass or feedstocks derived from biomass. The process of converting grain to ethanol produces a lipid-rich by-product known as bioethanol side-stream. The process begins with dry milling, wherein grains are ground into a fine flour. This flour undergoes liquefaction, during which it is combined with water, enzymes (typically α-amylase), and various processing aids to decompose starch into fermentable sugars, primarily glucose. The resulting glucose is fermented by yeast to produce ethanol. Following fermentation, ethanol is separated through distillation and dehydration, leaving behind a co-product known as stillage. This stillage undergoes centrifugation to separate the solid fraction (distillers' grains) from the liquid portion. The resulting liquid, known as lipid slurry (LS), is a crude mixture that is rich in lipophilic compounds (including waxes, polar lipids, free fatty acids, etc.). The LS is distinct from the purified distillers' corn oil that is extracted later through mechanical separation.

Although corn continues to be the primary grain for ethanol production, grain sorghum has gained popularity. Approximately one-third of the grain sorghum in the United States is used for ethanol production (Sorghum Checkoff, 2025). According to the Renewable Fuels Association (RFA), around 823,108 tons of sorghum were used for fuel alcohol production in the U.S. in 2024 (RFA, 2025b). Moreover, Dalby Biorefinery Ltd. in Australia utilizes 200,000 tons of red sorghum grain annually to produce approximately 76 million liters of fuel-grade ethanol (Dalby Bio-refinery Ltd., 2017).

As the bioethanol industry diversifies feedstocks and explores co-products, the LS shows promising potential beyond conventional fuel uses (Tuhanioglu et al., 2023). LS typically contains a complex matrix of waxes, free fatty acids, sterol derivatives, glycolipids, phospholipids, and carotenoids (Di Lena et al., 2020a; Di Lena et al., 2020b). Although distillers' corn oil is well-studied and commonly used in animal feed and biodiesel, corn/sorghum LS is not extensively researched, despite possessing greater chemical complexity (Moreau et al., 2010, 2011).

To promote the use of LS as a sustainable lipid source in food, cosmetics, and biofuel industries, it is crucial to employ eco-friendly methods for separating its various lipid components. Supercritical carbon dioxide (SC-CO_2) offers a green, residue-free alternative to conventional solvents, with a relatively low critical point (88 °F, 1073 psi) and tunable selectivity based on temperature and pressure (Sadaf et al., 2024). Its ability to fractionate specific lipid classes from complex matrices makes SC-CO_2 particularly well-suited for refining LS into high-value functional materials, including high-melting-point waxes (Tuhanioglu et al., 2023; Tuhanioglu et al., 2025). The goal of this study was to determine the SC-CO_2 sorghum wax fractionation yield from LS obtained from three distinct fermentation batches with different corn-sorghum ratios, enabling the commercialization of the proposed approach.

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[2] Assistant Professor, Department of Biological and Agricultural Engineering, Fayetteville.

Procedures

Materials

The liquid CO_2 (99.99% purity) and N_2 (99.9% purity) were purchased from Airgas, Inc. (Fayetteville, Ark., USA). Three batches of corn/sorghum-based post-fermentation lipid slurries (LS) were kindly provided by Western Plains Energy LLC. The standard chemicals were purchased from Thermo Scientific, Mass., USA (lutein, purity of 90%) and Sigma Aldrich, St. Louis, Mo., USA (zeaxanthin and beta-carotene, both purity of ≥95%). All other chemicals were of analytical grade.

SC-CO_2 Treatment

The optimal wax fractionation via SC-CO_2 has been extensively documented in our previous study (Tuhanioglu et al., 2023). Briefly, a laboratory-scale SC-CO_2 extractor (SFT-120, Supercritical Fluid Technologies, Inc., Newark, DE, USA) was employed for the fractionation of waxes (Fig. 1). A 10 g slurry was encased in two sheets of Whatman #42 filter paper at the bottom of a stainless-steel high-pressure vessel. The CO_2 system was subsequently flushed to eliminate any air from the vessel. To prevent freezing caused by the Joule-Thompson effect during the continuous flow of CO_2, the temperature of the needle and micrometering valves was maintained at 176 °F. After reaching the desired temperature (167 °F), the high-pressure pump pressurized the system to 5800 psi. Static extraction lasted 20 min before each run. The flow rate during dynamic extractions remained steady at 67 fl. oz/min (measured under ambient conditions) for 6 h. The extracts (oils) and leftover samples (waxes) in the vessel were weighed using gravimetric methods and stored at -4 °F until further analysis.

Solid Phase Extraction

Solid phase extraction (SPE) was employed to fractionate the lipid slurries into three distinct classes: neutral lipids (NL), glycolipids (GL), and phospholipids (PPL), following the protocol reported by Obeid et al. (2022). The separation was conducted using a 0.423 oz RediSep Gold high-performance silica column.

Differential Scanning Calorimetry (DSC)

Differential scanning calorimetry (DSC) was conducted using a Model Diamond Perkin-Elmer (Norwalk, CT, USA) instrument to determine the melting behavior of the crude slurries and the fractionations, as described by Tuhanioglu et al. (2023).

Color Determination

Color determination was conducted utilizing a calorimeter (MINOLTA CR-300, KONICA MINOLTA, N.J., USA). The results were expressed as L^*, a^*, and b^* values, which signify lightness/darkness, redness/greenness, and yellowness/blueness, respectively. Prior to use, the colorimeter was calibrated using a white calibration plate.

Carotenoids Determination

Carotenoids were determined based on the method described by Ahmadzadeh and Ubeyitogullari (2024), with minor modifications. An HPLC system (SPD-20 AV UV/VIS detector, SIL-10AF autosampler, a CTO-20 A column oven, Shimadzu Corp., Japan) equipped with a YMC 30-Carotenoid™ column (Pa., USA) was used for lutein, zeaxanthin, and beta-carotene detection.

Protein, Mineral, and Ash Content

The nitrogen content was determined according to AOAC 968.06-1969, which was then converted into crude protein content using a conversion factor of 6.25. Ash content was determined using AOAC Methods 923.03 (for flour) and 920.153 (for meat). The mineral content was determined following a modified AOAC Method 968.08.

Statistical Analysis

Statistical analyses were conducted utilizing JMP Pro (Version 18.0.0; SAS Software Institute, Cary, N.C., USA). To assess differences among group means, Tukey's multiple comparison test was applied at a significance level of $\alpha = 0.05$.

Results and Discussion

Corn and grain sorghum are fundamental cereals with wide economic importance, serving as key sources of food, livestock feed, and industrial oils. In the context of bioethanol production, a thorough examination of the lipid profiles of corn and sorghum-based LS is needed, given their critical relevance to food, cosmetic, and biofuel applications. Understanding these lipid profiles of LS is essential for upcycling these side streams and creating sustainable, novel materials.

Natural and Polar Lipids

It is crucial to note that LS compositions can vary based on several factors. These include the type of yeast used for fermentation, the types and ratios of corn and sorghum involved, and the use of solvents in the procedure (Di Lena et al., 2020b; Johnston and Moreau, 2017; Majoni and Wang, 2010; Moreau et al., 2010, 2011). The general lipid class distributions for the three LS batches obtained from different corn/sorghum ratios were diverse or similar to one another (Fig. 1 and Table 1). As expected, NLs constituted over 90% (w/w) of the total composition, which mainly encompassed triacylglycerols (TAGs), diacylglycerols (DGs), waxes (fatty alcohols, aldehydes, and esters), and hydrocarbons. Furthermore, the GLs made up ~3.5% of the lipid fraction. These compounds, often monogalactosyldiacylglycerol (MGDG) and digalactosyldiacylglycerol (DGDG), are intrinsic to plant cell membranes (Day, 2004). In summary, no statistical differences were detected among NL, GL, and PPL fractions ($P > 0.05$).

Color and Carotenoids

Colorimetric evaluation using the L^* a^* b^* system revealed differences ($P < 0.05$) among lipid fractions of varying corn/sorghum ratios (Table 2). Overall, as the proportion of sorghum increased($P < 0.05$), the L^* values compared to corn, reflecting a lighter appearance. Concurrently, b^* values, which correlate with yellowness, were lower ($P < 0.05$) at 26.38 in the C60-S40

sample compared to 53.66 in the C40-S60 sample. In contrast, the corn-dominant sample (C60-S40) exhibited the darkest color and had the highest *a** value (10.62), indicating a greater presence of red-toned pigments or perhaps oxidative coloration (Fig. 1). These findings are further supported by the carotenoid content measurements, showing that corn-heavy batches (C60-S40 and C50-S50) contained the highest total levels of free carotenoids (i.e., lutein, zeaxanthin, and beta-carotene) when compared to the sorghum-heavy (C40-S60) batch (Table 2). The corn-heavy batch C60-S40 contained 62.60 ± 1.07 ppm of lutein, 87.49 ± 1.38 ppm of zeaxanthin, and 152.26 ± 5.60 ppm of beta-carotene. The C50-S50 batch contained significantly higher levels of lutein (157.28 ±8.03) and zeaxanthin (105.42 ± 0.87), but lower levels of beta-carotene (74.83 ± 0.81). On the other hand, the C40-S60 batch contained lower ($P < 0.05$) levels of all three carotenoids, with zeaxanthin being the dominant pigment.

Minerals and Trace Components

Minerals and inorganic substances, such as ash, were found in low concentrations in these fractions (Table 3). Ash contents were around 0.02%, with no statistical difference among batches. In general, only a couple of minerals displayed significant differences. Sorghum-dominant batch (C40-S60) contained greater ($P < 0.05$) amounts of Ca, K, and Na with 66.3 ± 8.26, 60.6 ± 15.80, and 30.9 ±1.13 ppm, respectively. Additionally, while the average Al and Fe contents were the highest in C40-S60, the differences were borderline nonsignificant ($P = 0.06$). Lastly, the average P content of C50-S50 was the highest at 117.84 ± 26.64 ppm, though statistically nonsignificant due to the large standard deviation in C40-S60 ($P > 0.05$). This is likely attributable to the thick structure of the samples, particularly in comparison to the other two batches, which renders full homogenization challenging. It is worth noting that the value of P in the C50-S50 may correlate with its phospholipid content, which is also the highest ($P < 0.05$) on average (Table 1).

Differential Scanning Calorimetry (DSC)

The DSC thermograms of SC-CO_2-fractionated waxes derived from the C60-S40, C50-S50, and C40-S60 lipid slurry batches had different peaks under previously optimized conditions (167 °F, 5800 psi, 6 h) for carnauba wax alternative (Tuhanioglu et al., 2023; Fig. 2). As anticipated, the C60-S40 wax displayed a single, sharp endothermic peak at 180 °F, closely aligning with the previously reported value of 178 °F. The emergence of a minor shoulder before the peak onset (also noted in the previous studies) indicated a consistent extraction profile and reinforces the repeatability of the SC-CO_2 protocol for this particular batch. In contrast, the more sorghum-rich LS waxes (C50-S50 and C40-S60) displayed two broad, shoulder-to-shoulder peaks centered around ~133 °F and ~165 °F, with the higher-temperature peak exhibiting tailing toward 185 °F. Such broad, overlapping transitions are indicative of complex wax matrices containing multiple components with varying melting behaviors and potential intermolecular interactions. Despite the elevated sorghum content, which is typically associated with an increased yield of wax, the lack of a prominent peak at approximately 176 °F in these samples indicates incomplete or modified extraction dynamics. This deviation may result from increased matrix viscosity or density associated with sorghum-rich lipid systems, which likely hinders solute diffusivity and phase equilibrium under the optimized SC-CO_2 conditions for fractionation of waxes in C60-S40.

Practical Applications

This study demonstrates the potential of using various bioethanol by-products, which are waste materials rich in sorghum waxes, as a new and innovative source for producing commercial wax analogs. Additionally, it highlighted the efficiency and practicality of using pure SC-CO_2 as a green and solvent-free method for fractionation. The compositional and thermal behavior of bioethanol by-product (i.e., lipid slurry (LS)) was shown to be strongly influenced by the ratio of corn/sorghum. LS proved to be a minor source of protein, accounting for less than 0.5%. Thermal analysis demonstrated the repeatability of SC-CO_2 fractionation in the C60-S40 batch, yielding a distinct melting behavior similar to carnauba wax (melting peak at 180 °F). In contrast, the fractions rich in sorghum exhibited intricate, multi-phase melting behaviors, suggesting either incomplete separation (i.e., requiring further optimizations for the fractionation) or the co-extraction of amorphous components under pre-optimized conditions. It was also demonstrated that LS can be a significant source of carotenoids.

Acknowledgements

This work was supported by Arkansas corn and grain sorghum producers through check-off funds administered by the Arkansas Corn and Grain Sorghum Promotion Board. This project was also supported in part by the USDA National Institute of Food and Agriculture, Multistate Project NC1023, Accession number 1025907, and AFRI award no: 2023-67022-40164.

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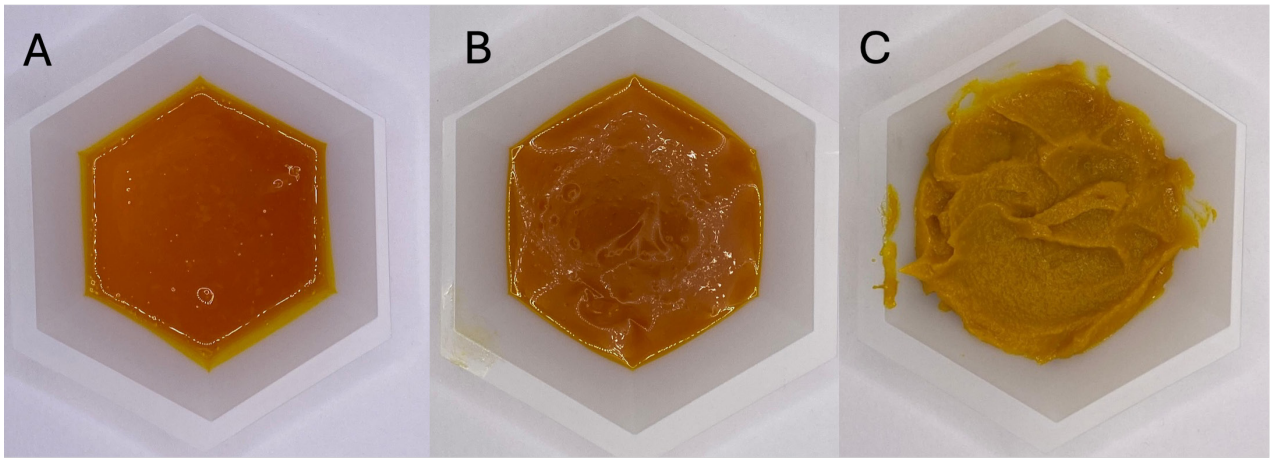


Fig. 1. Lipid slurry batches. A: C60-S40, B: C50-S50, C: C40-S60. C60-S40 (60% corn: 40% sorghum), C50-S50 (50% corn: 50% sorghum), and C40-S60 (40% corn: 60% sorghum).

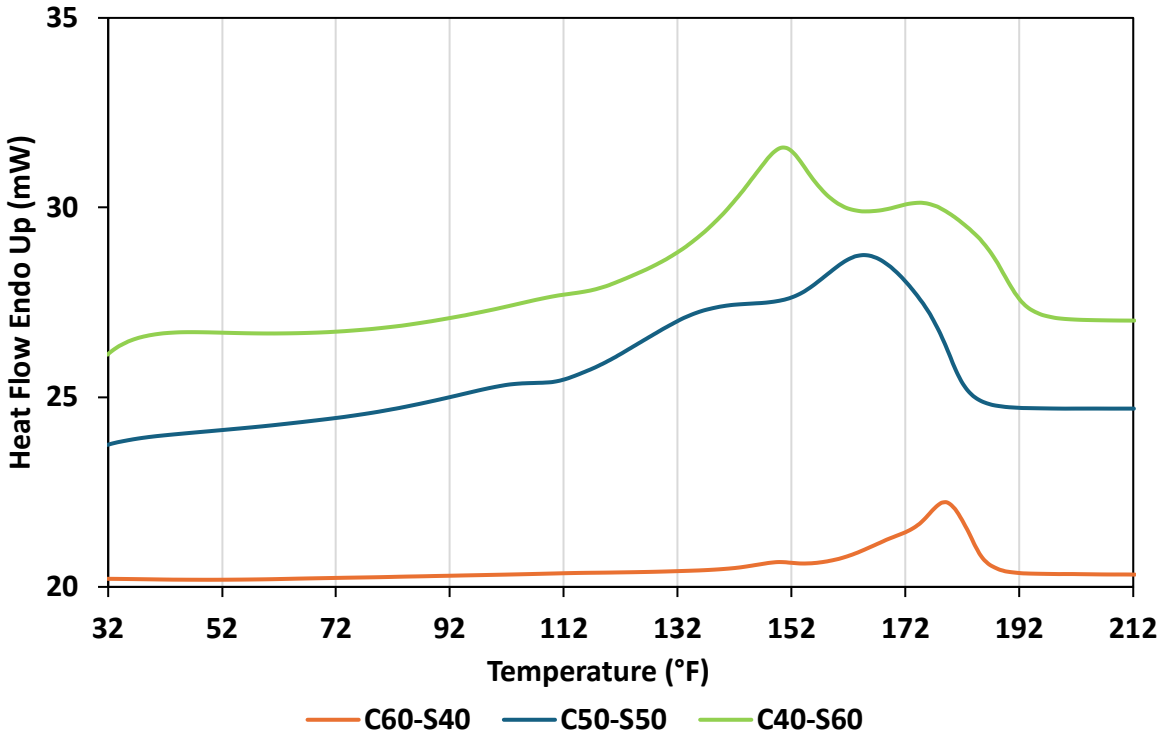


Fig. 2. Thermograms of SC-CO_2-fractionated waxes from lipid slurries.

Table 1. General lipid class composition of different batches of lipid slurries.

Batch no.	Natural Lipids	Glycolipids	Phospholipids	Residue	Filter Paper Suspended Fraction
	----------(%)----------				
C60-S40	91.90 ± 0.51 a[†]	3.69 ± 0.02 a	0.40 ± 0.30 a	2.26 ± 0.33 a	1.75 ± 0.14 b
C50-S50	93.21 ± 1.36 a	2.13 ± 0.50 a	0.61 ± 0.42 a	1.74 ± 0.21 a	2.32 ± 0.23 b
C40-S60	88.99 ± 2.13 a	3.40 ± 0.54 a	0.36 ± 0.08 a	3.91 ± 1.84 a	3.35 ± 0.18 a

[†] Means in the same column that are not connected by the same letter are significantly different ($P < 0.05$).

Table 2. Colorimetric parameters and carotenoid contents of different lipid slurries.

Batch no.	*L**	*a**	*b**	Lutein	Zeaxanthin	Beta-carotene
				----------(ppm)----------		
C60-S40	38.26 ± 0.47 c[†]	10.62 ± 0.71 a	26.38 ± 0.60 c	62.60 ± 1.07 b	87.49 ± 1.38 b	152.26 ± 5.60 a
C50-S50	40.59 ± 0.40 b	9.63 ± 0.15 b	30.22 ± 0.42 b	157.28 ± 8.03 a	105.42 ± 0.87 a	74.83 ± 0.81 b
C40-S60	54.69 ± 0.60 a	7.64 ± 0.13 c	53.66 ± 0.23 a	41.80 ± 3.62 c	80.37 ± 1.54 c	43.09 ± 0.59 c

[†] Means in the same column that are not connected by the same letter are significantly different ($P < 0.05$).

Table 3. Total protein, ash, and mineral compositions of lipid slurries.

Batch no.	Protein	Ash	Nitrogen	Al	Ca	Cu	Fe	K	Mg	Mn	Na	P	S	Zn
	----------(%)----------			----------(ppm)----------										
C60-S40	0.31 ± 0.03 a[†]	0.02 ± 0.01 a	0.05 ± 0.00 a	4.06 ± 0.33 a	24.63 ± 0.57 b	0.61 ± 0.14 a	9.15 ± 7.25 a	21.57 ± 0.69 b	ND	ND	18.09 ± 0.09 b	43.60 ± 1.08 a	<22.55	<0.34
C50-S50	0.40 ± 0.01 a	0.015 ± 0.01 a	0.065 ± 0.01 a	5.31 ± 1.75 a	28.84 ± 0.13 b	0.44 ± 0.01 a	13.33 ± 0.02 a	33.22 ± 0.18 ab	12.85 ± 1.39 a	ND	18.00 ± 0.24 b	117.84 ± 26.64 a	<18.85	<0.74
C40-S60	0.38 ± 0.04 a	0.015 ± 0.01 a	0.065 ± 0.01 a	9.0 ± 1.43 a	66.3 ± 8.26 a	ND	24.2 ± 1.36 a	60.6 ± 15.80 a	14.6 ± 5.22 a	ND	30.9 ± 1.13 a	86.7 ± 59.46 a	<117.00	<0.37

[†] Means in the same column that are not connected by the same letter are significantly different ($P < 0.05$).

Use of Gossypol from Cottonseed Oil to Inhibit Reproduction in Domestic Boars as a Model for Feral Hog Control

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Abstract

Feral hogs are an invasive species known to cause over $1.5 billion in total estimated damages to property, ecosystems, and agricultural operations, including crop production, in the United States. The overarching aim of the study was to develop a gossypol-containing cottonseed oil-based product that could be poured over any feed substrate as a bait to decrease the fertility of feral hogs in the state of Arkansas. In line with the overarching aim, the primary objective was to determine the effects of gossypol-containing cottonseed oil consumed by sexually mature domestic boars on health and semen quality parameters. The secondary objective focused on product development needs to implement necessary improvements to create a field-ready bait product. Results from the initial pilot study are summarized as follows. No behavioral signs of sickness were observed in boars consuming gossypol-containing cottonseed oil. Gossypol-containing cottonseed oil was effective at reducing measures of sperm motility and concentration after a 42-day treatment period and returned to similar concentrations as controls 70 days after the end of the treatment period. However, reduced feed intake was also observed, suggesting palatability issues with cottonseed oil. Further, identification of an alternative large-scale source of gossypol-containing cottonseed oil was determined to be necessary due to oil production and source limitations. Product improvements have been made to address these challenges, and an evaluation of the effectiveness of these improvements is in progress. This report summarizes findings and progress of the 3-year funding period. Preliminary results support the potential for a gossypol-containing cottonseed oil-based bait to be used as a contraceptive for feral hogs in the state of Arkansas.

Introduction

In the United States, feral hogs are known to cause over $1.5 billion annually in total estimated damages to property, ecosystems, and agricultural operations, including crop production. Feral hogs are an invasive species that pose a threat to the health of livestock, pets, wildlife, and people (USDA, 2020). Control practices, such as hunting and trapping, have been largely unsuccessful in reducing the exponential growth of the feral hog population. Reproductive control measures may provide a novel strategy to help reduce populations of feral hogs and alleviate damage in Arkansas. Gossypol is a naturally occurring polyphenolic compound in the cotton plant that has long been known to decrease fertility in various species (Gadelha et al., 2014; Randel et al., 1992). This report summarizes findings and progress to date of a 3-year study evaluating the use of a gossypol-containing cottonseed oil bait product developed by our laboratory group to inhibit the fertility of domestic boars as a model of reproductive control in feral hogs. The ultimate goal is for the developed bait to be used as a contraceptive to reduce feral hog populations in the state of Arkansas.

Procedures

In accordance with the primary objective, an initial pilot study was conducted to evaluate the use of gossypol-containing cottonseed oil on the health and reproductive function of domestic boars. Procedures of this study were previously reported by Turner and others (2024) in the Arkansas Corn and Grain Sorghum Research Studies 2024 publication and are briefly summarized as follows. Gossypol-containing cottonseed oil was tested at 3 concentrations: 4 mg gossypol/kg of body weight, 8 mg gossypol/kg of body weight, and 12 mg gossypol/kg of body weight. Treatments were administered for a 42-day treatment period, followed by a 70-day recovery period. During the recovery period, all boars were fed a diet without cottonseed oil. Sickness behavior, body weight, and semen quality were assessed every two weeks during both the treatment and recovery periods. In accordance with the secondary objective, proprietary product improvements were conducted to improve the palatability of the bait and source large-scale oil production options. Ongoing research is evaluating the effectiveness of these improvements.

Results and Discussion

As mentioned above, the results and discussion of the initial pilot study were previously reported by Turner and others in the Arkansas Corn and Grain Sorghum Research Studies 2024 publication and are briefly summarized as follows. There was no impact of gossypol treatment on sickness behavior in boars.

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In general, the health of animals consuming gossypol-containing cottonseed oil is an important consideration, due to concerns of potential consumption by non-target species. Our laboratory group will continue to evaluate measures of sickness behavior and blood parameters in ongoing projects as assessments of health. Measures of sperm motility and concentration were decreased after 42 days of treatment with gossypol-containing cottonseed oil. This is complementary to previous reports of decreased sperm motility in various species consuming gossypol (Randel et al., 1992). Reductions in sperm motility were maintained for approximately 28 days and increased back to similar concentrations as the gossypol-free treatment by day 70 of the recovery period. However, the treatment group that was administered the highest concentration of gossypol (12 mg gossypol/kg of body weight) had reduced feed intake and body weight, suggesting palatability issues with the cottonseed oil. Therefore, our laboratory group has begun working with a commercial company that specializes in swine feed additives to develop a customized additive to improve the palatability of the bait product. A secondary challenge was identified after the initial study. Specifically, the oil used in the initial study was produced solely by our laboratory group, using a small-scale oil press. This was necessary because there is no commercially available large-scale source of gossypol-containing cottonseed oil in the United States. The refining process used for large-scale cottonseed oil production in the United States is specifically designed to remove the gossypol from the oil. This limitation created a need to identify an alternative large-scale option to produce gossypol-containing cottonseed oil to develop a product that could be produced for commercial purposes. Our laboratory group has now successfully identified a large-scale source of gossypol-containing cottonseed oil. Research is currently in progress to evaluate the effectiveness of the additive to improve palatability and intake of the bait by domestic boars and barrows. The new source of cottonseed oil is being utilized in these studies. Additionally, the effectiveness of the improved bait product to inhibit semen quality in domestic boars is being evaluated to ensure replicable results from the initial pilot study. It is also important to note that in accordance with the original proposal objectives, our laboratory group continues to obtain input from 1) state and federal agencies and 2) collaborators in wildlife biology/population management to prepare for ongoing and future research phases.

Practical Applications

The overarching aim of the study was to develop a gossypol-containing cottonseed oil-based product that could be poured over any given feed substrate as a bait to decrease the fertility of feral hogs. Preliminary results showed decreased sperm motility and concentration after feeding gossypol-containing cottonseed oil for a 42-day treatment period. Based on results and procedural limitations identified in the initial pilot study, product improvements have been made with the goal of developing a field-ready bait product. Decreased sperm motility and concentration parameters have a direct application to reduce pregnancy rates and litter size in feral hog populations. These novel preliminary results suggest the potential for a gossypol-containing cottonseed oil bait to serve as a contraceptive for feral hogs and provide strong support for continued research in this area.

Acknowledgments

The authors would like to acknowledge funding from the Corn and Grain Sorghum Check-off Funds administered by the Arkansas Corn and Grain Sorghum Board, Soybean Check-off Funds administered by the Arkansas Soybean Research and Promotion Board, and support from the University of Arkansas Division of Agriculture.

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Corn and Grain Sorghum Enterprise Budgets

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Abstract

Crop enterprise budgets were developed to evaluate alternative production practices and cropping systems for Arkansas producers. Interactive budget programs utilize methods that are consistent across field crops grown in Arkansas. Production practices for base budgets are based on the University of Arkansas Division of Agriculture's Cooperative Extension Service (CES) recommendations from Jason Kelley, Extension Agronomist, supported by data from the Corn and Grain Sorghum Verification Program (CGSRVP). Crop budgets currently developed for users allow customization based on CES recommendations or on-farm production data. Economists utilize the budget program to conduct economic analysis of field data from various corn or grain sorghum research plots, as well as the CGSRVP. The crop enterprise budgets provide a tool for users to evaluate the financial implications of various field activities associated with crop production. Farm financial stress has become one of the top concerns of producers, and crop enterprise budgets help end users determine which practices are suited to their operations, ensuring positive cash flow. Currently, 12 corn and grain sorghum budgets are released each winter, with updates in the spring. Corn seed for the crop budgets is available as a stacked gene variety with full ownership and crop-share rent agreement versions. There are 3 main irrigation categories for corn: furrow-irrigated, center-pivot irrigated, and non-irrigated. Grain sorghum budgets are developed in a similar manner to corn budgets. The crop enterprise budget page averages over 20,000 page views annually, underscoring the importance of this research to Arkansas producers.

Introduction

Volatile input prices and supply availability of key herbicides and fertilizers pose challenges for producers when deciding on cropping systems for a farm. In 2005, total operating expenses for Roundup Ready furrow irrigated corn were less than $300/ac. By 2015, total operating expenses had increased by 211%, to $627.23/ac. Over the last decade, operating expenses increased from $181.57/ac to $808.80/ac in 2025. To sustain such cost growth, a producer would need to offset these expenses by increasing the prices received for corn. However, corn prices have remained stagnant and declined over the last decade. Low water levels on the Mississippi River crippled receiving inputs and exporting products to their desired markets in previous years and remain a concern moving forward. In the last crop season, timely rains helped ease concerns arising from severe droughts in 2023–2025 and allowed river terminal elevators to offer a basis premium. An ever-growing South American crop is keeping global corn prices suppressed. It is worth noting, though, that the corn-to-soybean ratio (if the ratio is >2.5, then it favors soybeans; if <2.5, then it favors corn) has remained neutral even with rallies in the soybean futures markets. The ratio had begun to weaken, or lean towards planting corn, until a late-fall futures market rally was seen in 2025. Producers need a means to calculate costs and returns of production alternatives to estimate potential profitability with ever-changing export markets, consumer spending habits, and input cost spikes. The objective of this research is to develop an interactive computational program that will enable stakeholders of the Arkansas corn and grain sorghum industry to evaluate production methods for comparative costs and returns, which allows for evaluating the profitability of managerial decisions.

Procedures

Methods employed for developing crop enterprise budgets include input prices estimated directly from suppliers, producers, and knowledgeable sources, as well as costs estimated using engineering formulas developed by the American Society of Agricultural and Biological Engineers. Input costs for fertilizers and chemicals are estimated by applying prices to typical input rates and tank mixes. Input prices, custom hire rates, and fees are estimated using information from industry contacts and bids from local suppliers. The methods for estimating these operating expenses presented in crop enterprise budgets are identical to those used by producers to obtain cost information for their specific farms. These prices, however, fail to factor in discounts for buying products in bulk, preordering items at a lower price, and other promotions available at the point of purchase.

Ownership costs and repair expenses for machinery are estimated by applying engineering formulas to representative prices of new equipment (Givan, 1991; Lazarus and Selly, 2002). Repair expenses in crop enterprise budgets should be regarded as value estimates of full-service repairs. Repairs and maintenance performed by hired farm labor will be partially realized as wages paid to employees. Machinery performance rates of field activities utilized for machinery costs are used to estimate the time requirements of an activity, which is applied

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to an hourly wage rate (in Arkansas, the H2A labor rate is estimated to have increased $0.30/hr from $14.53/hr for 2025 to $14.83/hr for 2026) for determining labor costs. Labor costs in crop enterprise budgets represent time devoted to all field activities associated with the crop, including irrigation. When information was not readily available, references have been added to the budgets using information from Mississippi State University (MSU, 2025).

Ownership costs of machinery are determined by the capital recovery method, which determines the amount of money that should be set aside each year to replace the value of equipment used in production (Kay and Edwards, 1999). This measure differs from typical depreciation methods and from actual cash expenses for machinery. Amortization factors applied for capital recovery estimation coincide with prevailing long-term interest rates (Edwards, 2005). Interest rates in this report are from Arkansas lenders as reported in fall 2025 for the 2026 crop season. Representative prices for machinery and equipment are based on contacts with Arkansas dealers, manufacturers' suggested retail prices (MSRP), industry list prices, and reference sources (Deere & Company 2025; MSU, 2025). Revenue in crop enterprise budgets is the product of expected yields from following CES practices under optimal growing conditions, combined with actual yield data from the CGSRVP and commodity prices received data from the National Agricultural Statistics Service (NASS).

Results and Discussion

The University of Arkansas Division of Agriculture's Department of Agricultural Economics and Agribusiness (AEAB) develops annual crop enterprise budgets to assist Arkansas producers and other agricultural stakeholders in evaluating expected costs and returns for the upcoming crop production year. The production methods analyzed represent typical field activities, as determined through consultations with producers within the state, County Agents, agronomists, weed scientists, plant pathologists, entomologists, and information from CGSRVP coordinators in the Department of Crop, Soil, and Environmental Sciences. Actual production practices vary greatly among individual farms due to management preferences believed to be the best methods for greatest success as stewards of the land. Analyses are for general circumstances, with a focus on the consistent and coordinated application of budget methods across all field crops. This approach results in meaningful cost and returns comparisons for decision-making related to acreage allocations among field crops. Results should be regarded only as a guide and a basis for individual farmers who wish to develop budgets based on their production practices, soil types, and other unique circumstances.

Table 1 provides a summary of revenue and expenses of the 2026 corn enterprise budgets. Costs are presented on a per-acre basis with an assumed yield of 215 bu./ac for furrow-irrigated corn and 105 bu./ac for furrow-irrigated grain sorghum. Price received for 2026 was set at $4.50/bu. for corn and $4.75/bu. for grain sorghum. This is a $0.05/bu. gain from $4.45/bu. in 2025 and $0.30/bu. below the 2024 crop value expectation of $4.80/bu. Program flexibility allows users to change total acres, yields, and prices received, among other variables, to represent many unique farm scenarios. Expected returns to operating expenses range from $140.41/ac (furrow irrigated corn) to -$70.15/ac (non-irrigated corn). With no positive net returns above operating costs expected in producing grain sorghum, it's likely that few acres will be planted in the upcoming season in Arkansas. Fixed costs for furrow-irrigated corn are $173.40/ac. Pivot irrigated corn has a fixed cost of $250.69/ac. No corn or grain sorghum budget developed; looking forward to the 2026 crop season, which covers fixed costs. A price of $4.66/bu. is needed to cover all costs in the furrow-irrigated corn budgets for 2026.

Practical Applications

Copies of the crop enterprise budgets are available to the public on the CES website, uaex.uada.edu. Once on the webpage, use the search tool and use keywords such as "crop budgets", "corn budget", etc., to locate the crop budget webpage. The crop budget webpage contains the most up-to-date crop budgets as well as information on historical budgets and farm machinery costs. The benefits of the economic analysis of alternative corn and grain sorghum production methods include a significant reduction in the financial risk producers face. Since 1 April 2025, the crop enterprise budget page has been viewed 20,179 times (as of 15 February 2026). Arkansas producers can use the budget program to develop economic analyses of their individual production activities. Unique crop enterprise budgets developed for individual farms are useful for determining credit requirements. Flexible crop enterprise budgets are useful for planning that determines production methods with the greatest potential for financial success. Flexible budgets enable farm financial outlooks to be revised during the production season as inputs, input prices, yields, and commodity prices change. Incorporating changing information and circumstances into budget analysis helps producers and lenders make decisions that manage the financial risks inherent in agricultural production.

Acknowledgments

Corn and grain sorghum budgets are possible thanks to the support from the check-off funds administered by the Arkansas Corn and Grain Sorghum Board, as well as the University of Arkansas Division of Agriculture. Thank you for your continued support of this project.

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Table 1. Summary of Revenue, Expenses, and Returns ($/acre) for furrow irrigated, pivot, and non-irrigated Corn and Grain Sorghum, 2026.

Receipts	Corn Furrow	Corn Pivot	Corn Non-Irr	Sorghum Furrow	Sorghum Pivot	Sorghum Non-Irr
Yield (bu./ac)	215	210	125	105	105	80
Price ($/bu.)	4.50	4.50	4.50	4.75	4.75	4.75
Grower Share, %	100%	100%	100%	100%	100%	100%
Crop Revenue ($/ac)	967.50	945.00	562.50	498.75	498.75	380.00
Operating Expenses ($/ac)						
Input Costs	610.16	613.11	475.80	424.04	420.96	299.63
Other Operating Expenses	120.19	141.81	100.59	97.59	111.67	71.66
Total Operating Expenses	730.34	754.92	576.40	521.64	532.63	371.29
Post-harvest Expenses	96.75	94.50	56.25	27.30	27.30	20.80
Net Operating Expenses	827.09	849.42	632.65	548.94	559.93	392.09
Cash Land Rent	0.00	0.00	0.00	0.00	0.00	0.00
Returns to Operating Expenses	140.41	95.58	(70.15)	(50.19)	(61.18)	(12.09)
Fixed Costs	173.40	250.69	120.31	141.29	194.45	97.55
Total Expenses[a]	1000.49	1100.11	752.96	690.23	754.38	489.64
Returns to Total Expenses	(32.99)	(155.11)	(190.46)	(191.48)	(255.63)	(109.64)

[a] Does not include land costs, management, or other expenses and fees not associated with production.

APPENDIX: CORN AND GRAIN SORGHUM RESEARCH PROPOSALS

2025–2026 Corn and Grain Sorghum Board Awards

Principle Investigator (PI)	Co-PI	Proposal Name	Year of Research	Funding Amount
J. Kelley	T. Faske and N. Slaton	Arkansas Corn and Grain Sorghum Research Studies Series, an Annual Report and Archival System for all Board-Funded Research	1 of 3	$4,800
J. Robinson		Arkansas Future Ag Leaders Tour	1 of 3	$5,000
B. Deaton		Economic Analysis of Corn and Grain Sorghum Production and Marketing Practices	1 of 1	$6,000
B. Watkins		Corn and Grain Sorghum Enterprise Budgets and Production Economic Analysis	3 of 3	$10,000
K. Brye	D. Lunga	Greenhouse Gas Data Summarization in a Corn Production System With and Without Cover Crops	1 of 1	$11,267
J. Davis	J. Kelley	Development and Verification of a Stand Counting Application Using Drone Imagery for Research and Production Decision Support	2 of 3	$16,360
B. Bluhm	K. Cartwright	Development, Evaluation and Production of Agricultural Biologicals for Arkansas Crop Production	1 of 3	$23,857
B. Littlejohn	C. Maxwell and T. Tsai	Use of Gossypol to Inhibit Reproduction in Domestic Hogs as a Model for Feral Hog Control	3 of 3	$30,000
E. Elli	J. Kelley	Refining Recommendations of Corn Hybrid Relative Maturity and Planting Dates in Arkansas	1 of 2	$32,537
J. Kelley	T. Roberts	Optimizing Plant Population and Nitrogen Rate in Corn	3 of 3	$34,000
G. Studebaker	N. Bateman and B. Thrash	Developing Effective Insect Pest Management Strategies for Arkansas Corn and Grain Sorghum	1 of 3	$39,964
T. Spurlock	J. Kelley, C. Nicolli, and J. Carlin	Determining Disease Resistance and Susceptibility of Corn and Grain Sorghum Hybrids	2 of 3	$40,000
T. Roberts	J. Kelley and G. Drescher	Cover Crops in Corn Rotations–What Works and What Doesn't?	3 of 3	$40,247
A. Ubeyitogullari		Generating a High-Value Wax Material from Sorghum Bran Using an Innovative Green Approach	2 of 3	$42,968
B. Bluhm	G. Johal	Towards a Comprehensive Aflatoxin Solution: Creating and Integrating Novel Aflatoxin Control Resources for an Effective, Sustainable Management Strategy	3 of 3	$45,000
M. Rahman		Innovative Application of Arkansas Corn: Replacement of Forever Chemicals in Food Packaging and Corn Gluten Meal	1 of 3	$45,150

Continued

2025–2026 Corn and Grain Sorghum Board Awards, continued

Principle Investigator (PI)	Co-PI	Proposal Name	Year of Research	Funding Amount (US$)
A. Poncet	T. Roberts and J. Kelley	Remote Sensing-Based Mid-Season Corn Nitrogen Fertilizer Rate Recommendations and Web-Tool Extension	2 of 3	$55,000
T. Faske	A. Greer and M. Emerson	Evaluate Management Options for Corn Nematodes in Arkansas	1 of 3	$58,383
T. Roberts	J. Kelley and G. Drescher	Fine-Tuning Potassium Recommendations and Investigating Intensive Tissue Analysis for Sustainable Corn Production	1 of 3	$74,876
T. Roberts	J. Kelley and G. Dresher	Improving Nitrogen Management for Arkansas Corn Production	2 of 3	$81,625
T. Barber	J. Norsworthy	Evaluation of Herbicides, Premixes, Programs, and Application Methods for Improved Control of Problematic Weeds in Corn	3 of 3	$86,150
J. Kelley	C. Capps, T. Faske, T. Spurlock, T. Roberts, T. Barber, G. Studebaker, B. Deaton, and C. Henry	Corn and Grain Sorghum Research Verification Program	2 of 3	$130,000
C. Henry	J. Kelley, T. Spurlock, and C. Capps	Improving Irrigation Technology for Corn Production in Arkansas	3 of 3	$185,280
			Total Awards	$1,098,464
C. Henry		The Arkansas Irrigation Yield Contest (Funded Separately)	Year 8	$10,000



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