Developing Profitable Irrigated Rotational Cropping Systems

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Abstract

A large-plot field trial evaluating the impact of crop rotation on yields of winter wheat (*Triticum aestivum* L.) and irrigated corn (*Zea mays* L.), early planted soybean [*Glycine max* (L.) Merr], double-crop soybean, full-season grain sorghum [*Sorghum bicolor* (L.) Moench] and double-crop grain sorghum was conducted from 2013–2019 at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station near Marianna, Arkansas. When compared to yields of continuously grown soybean, April planted group 4 soybean yields were greater in 3 out of 6 years when following corn or full-season grain sorghum, averaging 6 and 8 bu./ac, respectively. Crop rotation impacted June planted double-crop soybean yield 1 out of 6 years, and average yields were 4 bu./ac greater when following corn or grain sorghum than a previous double-crop soybean crop. Corn yields were impacted by the previous crop 1 out of 6 years, where corn following corn yield was 26 bu./ac lower than when following April planted soybean in 2016. On average, corn following corn yielded 6 and 7 bu./ac less than when following April planted soybean or double-crop soybean, respectively. Wheat yields were impacted by the previous crop in 3 out of 5 years of the trial. Wheat following full-season grain sorghum across all years yielded 7 bu./ac less than when following April planted soybean, and 4 bu./ac less when following corn or double-crop soybean. Full-season grain sorghum was always planted following April planted soybean or double-crop soybean, and yields averaged 114 bu./ac with no difference in yield between previous crops. Double-crop grain sorghum averaged 87 bu./ac across all years.

Introduction

Arkansas crop producers have a wide range of crops that can be successfully grown on their farms, including early-season group 4 soybean (typically planted in April), corn, full-season grain sorghum, wheat, double-crop soybean, double-crop grain sorghum, cotton, and rice depending on soil classification. As crop acreages in Arkansas have changed over the years due to grain price fluctuations and changing profitability, more producers are incorporating crop rotation as a way to increase crop yields and farm profitability. Crop rotation has been shown in numerous trials to impact crop yields. In studies near Stoneville, Miss., Reddy, et al., 2013, found that corn yields following soybean were 15%–31% higher than when corn was continuously grown; however, soybean yields were not statistically greater, but trended to higher yields when planted following corn. In Tennessee, Howard et al., 1998, found that soybean following corn yielded 11% higher than compared to continuous soybean and attributed soybean yield increases following corn to reduced levels of soybean-cyst nematodes. As crop acreage continues to shift based on economic decisions, more information is needed for producers on which crop rotation produces the greatest yields and profitability under mid-South irrigated conditions. There is a lack of long-term crop rotation research that documents how corn, soybean, wheat, and grain sorghum rotations perform in the mid-South. A comprehensive evaluation of crop rotation systems in the mid-South is needed to provide non-biased and economic information for Arkansas producers.

Procedures

A long-term field trial evaluating yield responses of eight rotational cropping systems that Arkansas producers may use was initiated at the University of Arkansas System Divisions of Agricultures' Lon Mann Cotton Research Station near Marianna, Arkansas in April of 2013. The following eight crop rotations were evaluated:

1. *Corn/Soybean/Corn/Soybean*. Corn planted in March or April each year followed by early-planted group 4 soybean planted in April the following year.
2. *Corn/Wheat/Double-Crop Soybean/Corn.* Corn planted in March or April, followed by wheat planted in October following corn harvest, then double-crop soybean planted in June after wheat harvest, and corn planted the following April.

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3. *Wheat/Double-Crop Soybean/Wheat.* Wheat planted in October, followed by double-crop soybean planted in June, then wheat planted in October.
4. *Full-Season Grain Sorghum/Wheat/Double-Crop Soybean/Full-Season Grain Sorghum*. April planted full-season grain sorghum, followed by wheat planted in October, then double-crop soybean planted in June after wheat harvest, then full-season grain sorghum planted the following April.
5. *Continuous Corn*. Corn planted in March or April every year.
6. *Continuous Soybean*. Early planted group 4 soybean planted in April every year.
7. *Full-Season Grain Sorghum/Early Planted Soybean.* Full-season grain sorghum planted in April, followed by April planted group 4 soybean planted the following year.
8. *Early Soybean/Wheat/Double-Crop Grain Sorghum/Soybean*. April planted group 4 soybean, followed by wheat planted in October, then double-crop grain sorghum planted in June after wheat harvest, followed by early planted group 4 soybean the following April.

The soil in the trial was a Memphis Silt Loam (Fine-silty, mixed, active, thermic Typic Hapludalf), which is a predominant soil type in the area. Crop rotation treatments were replicated 4 times within a randomized complete block design, and all rotation combinations were planted each year. Plot size was 25-ft wide (8 rows wide) by 200-ft long with a 38-in. row spacing. Before planting summer crops each year, plots were conventionally tilled, which included; disking, field cultivation, and bed formation by a roller-bedder so crops could be planted on a raised bed for furrow irrigation. Before planting wheat in October, plots that were going to be planted were disked, field cultivated and rebedded. Wheat was then planted on raised beds with a grain drill with 6-in. row spacing with a seeding rate of 120 lbs of seed/ac.

Soybean varieties planted changed throughout the trial. For April planted group 4 soybean, maturity ranged from 4.6 to 4.9 each year. Double-crop soybeans planted each year had a maturity range of 4.6 to 4.9. Corn hybrids varied by year and maturity ranged from 112 to 117 days. Full-season grain sorghum was Pioneer 84P80 from 2014-2018 and DKS51-01 in 2019. Double-crop grain sorghum hybrids grown included; Sorghum Partners 7715 and DKS 37-07, which are sugarcane aphid tolerant hybrids. In each year of the trial, Pioneer 26R41 soft red winter wheat was planted.

Summer crops were furrow irrigated as needed, according to the University of Arkansas System Division of Agriculture's Cooperative Extension Services' (CES) irrigation scheduler program. Normal production practices such as planting dates, seeding rates, weed control, insect control, and fertilizer recommendations for each crop followed current CES recommendations. Harvest yield data were collected from the center two rows of each plot at crop maturity, and remaining standing crops were harvested with a commercial combine. Soil nematode samples were collected at the trial initiation, and each subsequent fall after crop harvest and submitted to the University of Arkansas System Division of Agriculture's Nematode Diagnostic Lab at the Southwest Research and Extension Center at Hope, Arkansas. Soybean-cyst nematode was the only nematode that was found to be above economic thresholds levels during this trial, and levels were generally greater than 500 nematodes/100cm^3 of soil (data not shown). No root-knot nematodes were found in the trial area.

Results and Discussion

Soybean. April planted group 4 soybean yields were good each year with an average yield of 54–62 bu./ac depending on rotation over the 6 yr period (Table 1). The yield of April planted group 4 soybean was statistically impacted by the previous crop in 3 out of 6 years of the trial. Continuously grown soybean without rotation yielded 54 bu./ac on average, while soybean rotated with corn or full-season grain sorghum yielded 60 and 62 bu./ac, respectively (Table 1). Similar trends were noted with June planted double-crop soybean yields when following wheat. When double-crop soybean was following a previous crop of wheat/double-crop soybean, yields on average were only 40 bu./ac, while yields increased to 44 bu./ac when corn or full-season grain sorghum had been grown the previous year. However, double-crop soybean yields were only statistically influenced by the previous crop in 1 out of 6 years (Table 2). The yield differences of 60 bu./ac for early planted group 4 soybean following corn and 44 bu./ac for double-crop soybean following corn and wheat are similar to what many producers see on their farms between the early planted production system and the double-crop system. Differences in early planted and double-crop soybean yields between crop rotations can likely be attributed in part to lower soybean-cyst numbers following corn or grain sorghum each year (data not shown).

Corn. Corn yields were generally good over the 6 years and averaged 203–210 bu./ac depending on rotation (Table 3). Yields were statistically influenced by rotation in 1 out of 6 years with corn following corn yielding 26 bu./ac less than when following April planted group 4 soybean in 2016. Visually it was not apparent why there was a yield difference in 2016 as there were no notable differences in plant stands, foliar disease level, or late season lodging, and all inputs between rotations were constant. Over the 6-year period, corn following April planted group 4 soybean or June planted double-crop soybean yielded 6 or 7 bu./ac more, respectively than continuously grown corn. These results are similar to other trials in which corn is grown in rotation with soybean often yields more than if grown without rotation (Sindelar et al.,2015). As corn is grown continuously for more years without rotation, yields may decline greater, but that trend is not evident after 6 years of this trial.

Wheat. Wheat yields were generally good with an average yield of 65–72 bu./ac (Table 4), depending on rotation. Wheat yield was statistically influenced by previous crop 3 out of 5 years. When wheat was planted following full-season grain sorghum, yields were 7 bu./ac less on average than when following April planted group 4 soybean and 4 bu./ac less than when planted following June planted double-crop soybean or corn. The reason for lower wheat yields following full-season grain sorghum is not clear; however, fall and early winter growth was visibly reduced in some years. Grain sorghum has been reported to be possibly allelopathic to wheat under some circumstances. Although not definitive, allelopathy is suspected to have reduced wheat growth and yields in this study some years since all other management inputs such as tillage, seeding rate, fertilizer, foliar disease level, and plant stands were constant between treatments.

Grain Sorghum. Full-season grain sorghum was grown as a rotational crop and was always planted following soybean or double-crop soybean. Yields of full-season grain sorghum averaged 114 bu./ac and did not differ between the April planted group 4 soybean or double-crop soybean treatments over the 6-year period. State average grain sorghum yields generally range from 80–95 bu./ac. June planted double-crop grain sorghum following wheat averaged 87 bu./ac.

Practical Applications

Results from this on-going trial provide Arkansas producers with local non-biased information on how long-term crop rotation can impact yields of corn, early planted soybean, double-crop soybean, grain sorghum, double-crop grain sorghum, and wheat on their farms, which ultimately impacts the profitability of their farms.

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Table 1. Effect of previous crop on yield of April planted irrigated group IV soybean yield grown at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna, Arkansas, 2014-2019.

	Soybean Grain Yield						
Previous Crop	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Avg.**
	(bu./ac)						
April Planted Soybean	43	49	47	65	56	62	54
Corn	64	49	52	71	67	58	60
Full-Season Grain Sorghum	64	51	56	74	64	62	62
Wheat/Double-Crop Sorghum	--	50	54	71	65	58	60
LSD (0.05)	13	NSD†	NSD	6	6	NSD	--

† NSD = No Significant Difference at α = 0.05.

Table 2. Effect of previous crop on yield of June planted irrigated double-crop soybean grown following wheat at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna, Arkansas 2014-2019.

	Double-Crop Soybean Grain Yield						
Previous Crop	**2014**	**2015**	**2016†**	**2017**	**2018**	**2019**	**Avg.**
	(bu./ac)						
Double-Crop Soybean/Wheat	30	38	46	46	43	45	41
Corn/Wheat	39	43	49	48	46	47	45
Grain Sorghum/Wheat	40	42	50	48	46	46	45
LSD (0.05)	4	NSD‡	NSD	NSD	NSD	NSD	--

†Wheat was not planted during the fall of 2015, but soybean were planted in June 2016 during the normal time for double crop planting.

‡ NSD = No Significant Difference at α = 0.05.

Division of Agriculture's Lon Mann Cotton Research Station, Marianna, Arkansas 2014-2019.

	Corn Grain Yield						
Previous Crop	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Avg.**
	(bu./ac)						
April Planted Soybean	250	221	207	205	196	181	210
Wheat/Double-Crop Soybean	250	214	198	207	199	186	209
Corn	245	224	181	201	191	173	203
LSD (0.05)	NSD†	NSD	20	NSD	NSD	NSD	--

† NSD = No Significant Difference at α = 0.05.

Table 4 Effect of previous crop on yield of winter wheat grown at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna, Arkansas 2014-2019.

	Wheat Grain Yield						
Previous Crop	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Avg.**
	(bu./ac)						
April Planted Soybean	75	72	--	76	67	69	72
Double-Crop Soybean	75	69	--	73	64	64	69
Corn	72	68	--	74	69	61	69
Full- Season Grain Sorghum	69	73	--	56	62	65	65
LSD (0.05)	NSD†	4	--	12	6	NSD	--

† NSD = No Significant Difference at α = 0.05.

Table 5. Yield of irrigated full season grain sorghum and double crop grain sorghum grown at the University of Arkansas System Division of Agriculture's Lon Mann Cotton Research Station, Marianna, Arkansas 2014-2019.

	Grain Sorghum Grain Yield						
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**Avg.**
	(bu./ac)						
Full-Season Grain Sorghum	143	123	113	99	98	106	114
Double-Crop Sorghum	--	88	92	86	87	81	87