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Photo Credit: A research combine being operated in the field at the University of Arkansas System Division of Agriculture's Rice Research and Extension Center, Stuttgart. Photo taken by Professor Xueyan Sha.

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The Benefits of the Arkansas Rice Check-Off Program

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Abstract

As margins are reducing for agricultural producers there is a concerted effort to analyze all costs. One such cost for rice producers in Arkansas is their contribution to the Rice Check-off Program. This study analyzes the cost-benefit ratio of funds contributed by Arkansas rice producers and the holistic (both economic and environmental) benefits they receive. This study analyzes just five of the many programs the Rice Check-off Program invests in through the University of Arkansas System Division of Agriculture (UASDA) and suggests that every dollar invested generated an average return of $28.49 between 2002–2018 ($70.45 when ecosystem benefits are included). That being said, our benefit-cost ratios of 28.49 to 1 and 70.45 to 1, are conservative estimates as we are comparing the total Rice Check-off funding provided to the UASDA to the benefits of just five of its funded programs. These same investments have resulted in an increase in the rice supply sufficient enough to feed 4.15 million people annually. Rice Check-off funds have consistently provided substantial benefits from their investments.

Introduction

The Arkansas Rice Check-off

The Arkansas Rice Research and Promotion Board (Rice Check-off Program) was established in 1985 to improve the profitability of growing rice in Arkansas by conducting a program of research, extension, and market development. Currently, the board allocates funds collected from an assessment of 1.35 cents per bushel of rice grown in Arkansas paid by the grower and an assessment of 1.35 cents per bushel paid by the first buyer. The funds raised by the grower assessment are reserved for the research program, while buyer funds are reserved for domestic and international promotion and market development activities. Annual collections from rice producers vary with annual production. Over the last 20 years, grower check-off contributions have funded an average of $2.9 million in research and education programs coordinated primarily by the University of Arkansas System Division of Agriculture (UASDA). Research focuses on variety development (breeding), pest control, fertilization, environmental concerns, and pathology, to name a few.

This study analyzes the market and environmental benefits generated by the Rice Check-off Program between 2002 and 2018 by funds received by the UASDA through increased production and production efficiencies. This analysis does not include those funds, and subsequent benefits, from rice buyers which are targeted at rice promotion. The study quantifies the tangible benefits, such as yield enhancements and cost of production reductions, as well as the less tangible benefits regarding areas like ecosystem services, global food security, and international competitiveness. Studies such as this are vital for the Arkansas rice industry to understand the returns from investments in the Check-off-funded research and education programs.

Yield Enhancing Research

Rice Breeding

The University of Arkansas System Division of Agriculture has one of the few public rice breeding programs in the United States. Since 1984, the UASDA has released over 20 varieties aimed at increasing yield, milling quality, and other quality characteristics that increase international competitiveness. Acreage of UASDA varieties in Arkansas was at a high in 2003 (61%) and was reported at 22% of total Arkansas acreage in 2018. Between 1983 and 2016, the UASDA rice breeding program increased yields by 0.35% annually and did not come at the expense of milling quality (Shew et al., 2018). Importantly, the genetic yield gains from the UASDA breeding program have not plateaued, which is encouraging for rice producers and global food security.

Pathology

Check-off funds used for pathology research are correlated with the adoption of UASDA released varieties, as the benefits of improved disease tolerance are expressed in UASDA lines. Sheath blight, blast, bacterial panicle blight, smut, and leaf spot are just some of the diseases in which UASDA researchers are making advances. This study focuses on the Check-off funds allocated for research targeted at increasing resistance to blast and sheath blight.

Rice blast is responsible for approximately 30% of rice production losses globally—the equivalent of feeding 60 mil-

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lion people (Nalley et al., 2016). It is both difficult and time consuming for rice breeders and pathologists to breed for resistance to current strains of blast since the pathogen evolves and mutates to overcome resistance genes. Like blast, breeding rice for sheath blight resistance is difficult because the fungus continuously evolves, making even short-term resistance difficult to achieve. With the support of the Check-off program, UASDA pathologists and breeders have continuously worked to increase resistance to both blast and sheath blight. While not all UASDA varieties are resistant to blast or sheath blight, the level of resistance is higher than otherwise would be given the work of UASDA scientists. Previous research (Nalley et al., 2016; Tisboe et al., 2017) found that the average gain associated with pathology research funded by the rice Check-off for blast and sheath blight amounted to 3.04 bu./ac and 8.21 bu./ac, respectively.

Insecticide Seed Treatments

Rice water weevil and grape colaspis are common pests in Arkansas rice that have the potential to reduce stands, plant vigor, and subsequent yield. With funding from the Rice Check-off program, UASDA entomologists have worked to develop seed treatment recommendations that mitigate the effects of water weevil and grape colaspis damage on rice stands and yields. Insecticide seed treatments (IST) not only improve stands, but also increase yields 80% of the time for Arkansas rice producers (Taillon et al., 2016). This allows rice producers the flexibility of choosing lower seeding rates to reduce input costs while still maintaining profitability. Yield gains of 8.33 bu./ac are associated with IST research supported by the Rice Check-off program.

Cost Reducing Research

Multiple-Inlet Rice Irrigation

Side-inlet or multiple-inlet irrigation (MIRI) is an alternative to traditional flooded or single-inlet rice. Rather than discharging water directly from the well or riser into the paddy, with MIRI the riser is connected to poly pipe, and gates or holes are placed in the pipe for each paddy. With MIRI, each paddy is watered concurrently instead of receiving overflow from a higher paddy. By adjusting the gates, a producer can fill all paddies simultaneously. Since it is not necessary to overfill the paddies, MIRI reduces water losses due to deep percolation and seepage through the outside levees. Given that with MIRI each paddy fills at the same time, it is possible to apply the exact amount of water needed without runoff. Being able to quickly flood a field is beneficial for maintaining good weed control and maximizing nitrogen fertilizer efficiency.

Through Rice Check-off funding, UASDA researchers have conducted applied research, irrigation roundtable discussions, extension meetings, irrigation water management schools, released factsheets, and created a mobile app, called "Rice Irrigation" for producers regarding the benefits of MIRI. The mobile app, funded by the Rice Check-off program and developed by Chris Henry, provides rice farmers with an easy way to develop a MIRI plan.

Previous research found that compared to traditional flooding, MIRI used 23.8% less water with no yield penalty (Massey et al., 2018). Saving water has benefits that span beyond the obvious water savings and the reduction in energy costs for irrigation. That is, the value of the saved water, which will likely be used on a future crop, needs to be accounted for. Research by UASDA scientists found that an acre-inch of water in the Alluvial Aquifer is worth $1.97 (Kovacs and Durand-Morat, 2020). Thus, MIRI not only reduces costs, but it also provides future benefits in terms of conserving water that will be used at a later date. MIRI adoption has grown from 17.4% in 2002 to 33.2% in 2018 (B.R. Wells Arkansas Rice Research Studies, various years).

Nitrogen-Soil Test for Rice (N-STaR)

Nitrogen (N) fertilizer and application costs accounted for 12% of variable production costs and represented the single largest production expense for Arkansas rice production in 2019. Traditionally, N fertilizer recommendations are based on a combination of three factors: soil texture, cultivar, and previous crop. By providing a better way to assess the soil's ability to supply N, the Nitrogen-Soil Test for Rice (N-STaR) is a valuable tool to improve fertilizer-N use efficiency. N-STaR is a soil-based N test that quantifies the amount of N that will become available to the rice crop during the growing season. The N-STaR's success is attributed to its unique ability to selectively quantify soil organic-N compounds, which are readily mineralizable for plant uptake and contribute to rice growth and yield. Through Check-off funded research conducted by UASDA researchers, N-STaR has reduced N application by an average of 42 lb/ac for 83% of the enrolled fields in the N-STaR program (Davidson et al., 2016). The benefits of a soil N test are not just about optimizing economic or agronomic returns, but making environmentally sound N fertilization decisions. Thus, it is also important to evaluate the ecosystem services that programs like N-STaR provide by reducing nutrient loss.

Ecosystem Services from Check-off Research

Beyond input reducing (cost savings) and revenue increasing (yield-enhancing) programs, the Rice Check-off funding also provides environmental services. As the ratio of outputs to inputs increase, rice producers become more efficient in producing rice. This also means growers become more efficient at using inputs. These increases in efficiencies lead to a reduction in ozone depletion, global warming potential, eco-toxicity, carcinogens, etc., all associated with producing a bushel of rice. Like the future value of saved water, ecosystem services are "recognized" as being important but rarely quantified and used in estimating the benefits of Check-off funds. Using a Life Cycle Assessment (LCA), this study quantifies the value of ecosystem services from 2002–2018 contributed by the stated benefits specific to these five programs. The counterfactual question is asked, "If the Arkansas Rice Check-off program did not exist, how much more ecosystem damage would have occurred per bushel of rice produced?" Effects on human health are quantified by quality-adjusted life years, a measure of costs associated with morbidity and mortality, and ecosystem quality is quantified by biodiversity-adjusted acre years, a measure of costs associated with biodiversity loss, both of which are put into dollar terms.

Results

Using the estimated benefits per acre described above and the adoption rates described below, the total benefits of the five programs are quantified. For the sake of brevity, mathematical calculations were excluded but can be provided by the authors upon request. All additional costs for on-farm program implementation are accounted for.

Table 1 illustrates the adoption rates of each of the Check-off-funded programs described above. The IST acreage existed prior to 2012, but data was not available for benefit estimations. Pathology and Breeding acreage (area planted to UASDA varieties) are identical as the pathology benefits funded by the Check-off program express themselves via UASDA rice varieties. Table 2 highlights the estimated benefits from each program. Total benefits are estimated to be $1.55 billion (2018 USD) with an annual average benefit of $91.43 million. It is important to note that benefits should not be compared across research programs as some programs lend themselves to generate large upfront benefits, while others may provide benefits that are more evenly distributed in time or have larger impacts as constraints like water become more binding.

Benefit-Cost Ratio

While $1.55 billion in benefits is large by any definition, it is important to put these benefits in context. A benefit-cost ratio (BCR) is just that, a ratio of the benefits of and investments in a program. This report compares the benefits of just five of the many research programs to the total annual Rice Check-off funds. Some Rice Check-off programs are vitally important to the Arkansas rice industry, such as Farm Bill, trade, and policy analysis, but their benefits do not lend themselves to be easily quantified. There are many research programs funded by the Rice Check-off program that play integral roles in the success of Arkansas rice producers that are not quantified in this report. Their importance cannot be understated and continued funding is paramount for producer profitability moving forward. That being said, our BCR is a conservative estimate as we are comparing the total Check-off funding to the benefits of just

Table 1. Acreage associated with Arkansas Rice Check-off funded research programs.

Year	Breeding[a] (acres)	Pathology[b] (acres)	IST[c] (acres)	MIRI[d] (acres)	N-STaR[e] (acres)
2002	781,560	781,560		27,041	
2003	829,350	829,350		37,311	
2004	839,700	839,700		44,216	
2005	935,370	935,370		52,070	
2006	631,400	631,400		39,085	
2007	675,750	675,750		41,924	
2008	708,381	708,381		52,504	
2009	479,443	479,443		64,903	
2010	375,814	375,814		83,241	
2011	75,241	75,241		49,877	
2012	159,965	159,965	746,585	51,155	
2013	186,073	186,073	649,040	37,846	341,392
2014	227,985	227,985	1,047,840	60,601	494,943
2015	254,327	254,327	870,134	54,197	469,602
2016	396,981	396,981	1,154,439	52,057	518,542
2017	225,629	225,629	811,440	38,127	525,033
2018	288,322	288,322	1,050,858	48,816	428,399

[a] Denotes total acreage of University of Arkansas System Division of Agriculture (UASDA) varieties in Arkansas. This is an underestimate to total UASDA acreage as surrounding states (Louisiana, Mississippi, Missouri, and Texas) have historically planted UASDA varieties. (B.R. Wells Arkansas Rice Research Studies, various years).

[b] Denotes total acreage in which UASDA pathology benefits are expressed. This is equivalent to the acreage in which UASDA varieties are planted.

[c] Total acreage of insecticide seed treatments (IST) in Arkansas. (B.R. Wells Arkansas Rice Research Studies, various years)

[d] Acreage under multiple-inlet irrigation (MIRI) production in Arkansas directly attributed to Check-off funding. This is equivalent to 10.34% of total MIRI acreage.

[e] Total acreage under Nitrogen-Soil Test for Rice (N-STaR).

five programs. To give a sense of disparity, the five programs analyzed in this report account for between 35.8% and 72.7% of total Rice Check-off funding annually. Other funds are allocated to important research programs like fertility, post-harvest quality, the Rice Research and Verification Program, and weed science. Each plays an important role in the success of the Arkansas rice industry but were not captured in this study. The programs analyzed in this study were selected because they had both verifiable adoption rates and impact assessments.

Table 3 indicates that on average, between 2002 and 2018, every dollar invested into research from the Rice Check-off program resulted in $28.49 created through reduced costs, increased revenue, or both. That is, the BCR is equal to $28.49 to 1. When the ecosystems benefits are accounted for in Table 3, the BCR increases to $70.45 to 1. The estimated ecosystem service benefits attributed to the Rice Check-off program are actually larger than the sum of the other benefits combined. These results should be viewed cautiously as these benefits are not solely captured by Arkansas rice producers but society as a whole, via metrics such as less greenhouse gas emissions associated with rice production. Input reducing research programs such as MIRI and N-STaR are large contributors to these ecosystem services. Failing to account for these ecosystem services reduces the BCR by 247%. Again, while there is no current market for ecosystems services, besides a thinly traded carbon credit market, as regulations and environmental policies tighten, metrics like ecosystems services may become more pertinent in benefit-cost analyses. To put these BCRs into context, literature estimated the BCRs for soybeans and grain sorghum, the only two grains with a national check-off program, to be 12.34:1 and 8.57:1, respectively. Although not a straight comparison, Arkansas Rice Check-off funds invested by growers in research and education programs have a 230% and 333% larger return than funds invested in the national soybean (Kaiser, 2020) and sorghum (Capps et al., 2017) check-off programs, respectively.

Additional Benefits of Rice Check-off Funds

Agriculture's explicit goal is to feed humanity. Using the RiceFlow model (Durand-Morat and Wailes, 2010) and the estimated additional rice produced via enhanced produc-

Table 2. Benefits (in 2018 U.S. dollars, US$) associated with Arkansas Rice Check-off funded research programs.

Year	Breeding Benefits[a]	Pathology Benefits[b]	IST Benefits[c]	MIRI Benefits[d]	N-STaR Benefits[e]	Total Benefits
	(US$)	(US$)	(US$)	(US$)	(US$)	(US$)
2002	25,633,150	33,952,140		402,489		59,987,779
2003	52,068,863	62,094,030		606,351		114,769,244
2004	51,279,046	46,051,007		721,661		98,051,714
2005	58,164,782	61,623,822		1,004,303		120,792,908
2006	52,979,352	46,503,083		794,314		100,276,749
2007	75,365,570	59,732,788		878,742		135,977,099
2008	104,331,120	51,997,000		1,339,952		157,668,072
2009	59,280,055	35,277,165		1,287,517		95,844,737
2010	38,184,715	27,718,427		1,588,896		67,492,039
2011	9,858,153	6,469,370		1,007,407		17,334,930
2012	22,562,781	21,126,887	26,112,175	1,163,559		70,965,401
2013	26,791,253	26,041,505	25,015,735	917,725	7,486,894	86,253,112
2014	26,381,191	24,168,041	28,394,910	1,372,284	11,933,932	92,250,358
2015	27,614,269	24,815,538	21,666,796	1,238,460	8,991,709	84,326,772
2016	38,132,193	34,636,332	21,787,949	876,721	8,134,469	103,567,663
2017	18,343,472	19,697,477	18,542,283	645,741	7,996,893	65,225,867
2018	24,904,328	23,475,635	26,202,205	889,546	8,072,696	83,544,410
Total	711,874,294	605,380,246	167,722,053	16,735,669	52,616,593	1,554,328,854
Average	41,874,958	35,610,603	23,960,293	984,451	8,769,432	91,431,109

[a] Breeding benefits account for yield gain and associated annual rice price.
[b] Pathology benefits account for yield gain and associated annual rice price.
[c] Accounts for yield gain and associated additional seed treatment cost. Some private industry funding was used in the development of insecticide seed treatments (IST) and as such only 80% of estimated benefits were associated with the Rice Check-off program.
[d] MIRI = multiple-inlet irrigation. Accounts for cost savings from reduced irrigation requirements, additional poly-pipe costs, and future value of water.
[e] NSTaR = Nitrogen-Soil Test for Rice. Accounts for value of reduced N applications and respective annual nitrogen price, reductions in split applications of N for conventional rice seed, and additional testing costs.

tivity from the Rice Check-off funded research and education programs, it is estimated that this additional supply is enough to feed 4.15 million people every year at the average global rice consumption rate of 119.05 lb per person. This is worth reiterating, Rice Check-off funds are responsible for providing rice rations for 4.15 million people annually. Another way of looking at this is, without Arkansas Rice Check-off funding, 4.15 million rice rations would be lost annually, contributing to global food insecurity. This is another example of benefits that are obviously important but difficult to internalize in a BCR.

The RiceFlow model estimates that without the yield enhancements and cost-saving benefits generated by the five rice research programs analyzed in this study, U.S. long-grain rice production would be 5.3% lower than the current baseline and long-grain rice exports would be 9.8% lower. If the Rice Check-off research funds had not existed from 2002–2018, supply would decrease, and price would increase, reducing our global competitiveness. Table 4 indicates that if the research funds from the Arkansas Rice Check-off program were removed, the United States would lose market share in some of our largest export markets (Durand-Morat and Wailes, 2010). It is estimated that the United States would lose 4.6% of its exports to Haiti, 3.9% of its total exports to Mexico, and 24.8% of its exports to Venezuela. While the explicit goal of the Check-off research funds is not market promotion, the additional rice produced through these funds allows the U.S. rice industry to be more competitive and capture increased market share.

Summary

Rice Check-off funds have consistently provided substantial benefits from their investments. Every dollar invested in the UASDA through the Rice Check-off program generated an average of $28.49 between 2002–2018 and increase to $70.45 when ecosystem benefits are included. These Benefit Cost Ratios of 28.49 to 1 and 70.45 to 1 are conservative estimates as we are comparing the total Check-off funding provided to the UASDA to the benefits of just five programs. As important are the benefits which are harder to quantify with a dollar value, such as the fact that, on average, Rice Check-off funds provide enough additional rice to feed 4.15 million people annually. These results do not account for benefits from Rice Check-off funds provided to the USA Rice Council to represent Arkansas rice in the domestic and global marketplace.

It is important not to compare benefits across programs as some are reactive and address current needs, with large upfront benefits, and some are proactive and will likely have large benefits in the future. It is evident that the Rice Check-off program is a blend of proactive and reactive research. Reactive research includes activities that address, for example, the infestation of

Table 3. Benefit-cost ratio (BCR) with and without ecosystem services associated with Arkansas Rice Check-off funded research programs.

Year	Total Benefits[a]	Total Cost[b]	BCR[c]	Ecosystem Services	BCR with Ecosystem Services
	(US$)	(US$)		(US$)	
2002	59,987,779	3,479,841	17.24	133,999,505	55.75
2003	114,769,244	4,132,485	27.77	133,231,405	60.01
2004	98,051,714	4,025,290	24.36	149,697,314	61.55
2005	120,792,908	3,758,458	32.14	150,155,962	72.09
2006	100,276,749	3,738,816	26.82	133,693,446	62.58
2007	135,977,099	3,027,690	44.91	133,072,422	88.86
2008	157,668,072	3,032,369	52.00	128,973,994	94.53
2009	95,844,737	3,043,196	31.49	132,812,283	75.14
2010	67,492,039	3,134,576	21.53	159,084,839	72.28
2011	17,334,930	3,184,900	5.44	109,674,008	39.88
2012	70,965,401	2,837,605	25.01	126,420,842	69.56
2013	86,253,112	2,796,641	30.84	111,622,350	70.75
2014	92,250,358	3,008,144	30.67	154,261,490	81.95
2015	84,326,772	3,174,633	26.56	132,348,552	68.25
2016	103,567,663	2,615,621	39.60	139,499,641	92.93
2017	65,225,867	3,104,007	21.01	119,103,770	59.38
2018	83,544,410	3,096,950	26.98	140,115,072	72.22
Total	1,554,328,854	47,578,896	-	2,287,766,896	-
Average	91,431,109	3,246,542	28.49	134,702,399	70.45

[a] From Table 2.
[b] Total research funds allocated from the Arkansas Rice Check-off program to research in 2018 US$.
[c] Total annual benefits divided by total annual cost.

a new pest or disease that is currently affecting producer and industry profitability. Funds directed at reactive research typically have more tangible and widespread adoption than proactive research. Producers often like reactive research as it solves today's problem, and results are captured quickly. However, effective check-off programs should invest in projects that will affect future profitability. Proactive research for issues such as climate change, water scarcity, etc., will allow rice producers and the rice industry to stay profitable and competitive in the future. Proactive research is often funded at a lesser amount than reactive research, but a careful balance is needed to ensure future industry sustainability.

When policymakers, scientists, commodity boards, and producers are evaluating research they should look deeper than the cost savings and yield enhancements and look at the holistic economic impact. Water and fertilizer-N savings along with ecosystems services have historically been acknowledged (by producers) but seldom quantified (by academics) in previous benefit-cost ratios. Our research indicates that failure to both recognize and quantify these benefits can grossly underestimate the impact of research and its benefits.

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Table 4. Changes in import sourcing by the U.S. top five export markets of long-grain rice due to the removal of the benefits of the Arkansas Rice Check-off program.

Exporter/Importer	Mexico	Haiti	Canada	Colombia	Venezuela	Total
	Change from Baseline (thousand metric tons, milled basis)					
U.S.	-23.8	-16.0	-5.8	-14.9	-35.1	-224
Percent Change from Total Exports	(-3.9%)	(-4.6%)	(-2.7%)	(-8.9%)	(-24.8%)	(-9.8%)
MERCOSUR[a]	9.0	0.0	0.0	1.5	26.7	30
India						69
Thailand	5.0		2.6			18
Vietnam	5.0	12.0	0.5			32
Others	-5.5	3.6	2.0	0.9	-25.7	26.0
Net import change	-1.3	-0.4	-0.7	-11.0	-2.3	-49

[a] MERCOSUR rice exporting countries include Argentina, Brazil, Paraguay, Uruguay, and Venezuela.

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