# Table of Contents

## Arkansas Rice Case Study

- Executive Summary
  - 1. Market Dynamics
  - 2. Leadership
  - 3. Research & Varietal Development
  - 4. Demand Planning & Operations
  - 5. Financial Sustainability
  - 6. Enabling Environment

## Appendix
Executive Summary
University of Arkansas Breeding Program Enables the Seed System

VARIETAL DEVELOPMENT & SEED DEPLOYMENT

**Varietal Development**

Varietal development for Arkansas rice is conducted through the University of Arkansas System’s Division of Agriculture and is supported by check off funds collected by the Arkansas Rice Research and Promotion Board, as well as through grant funding and other state and federal funding sources.

**Seed Multiplication**

All breeder and foundation seed multiplication occur as part of the Arkansas Foundation Seed Program at the Rice Research & Extension Center (RREC). The Foundation Seed Program also works closely with the Arkansas Division of Agriculture’s Crop Variety Improvement Program when increasing new varieties.

**Certified Seed Production**

Certified seed production is performed by ~60 commercial seed growers that purchase foundation seed from the Arkansas Foundation Seed Program. These growers are members of the Arkansas Seed Growers Association and their seed is sold by members of the Arkansas Seed Dealers Association, which provides advocacy, coordination, and regulatory functions for seed production.

FARMER PRODUCTION, MARKETING, AND KEY DEMAND SEGMENTS

**Farm Production**

There are more than 2,500 rice farms in the state of Arkansas, and 96% of them are family owned. In 2017, over 1.5 million acres of rice were farmed in the state. The Arkansas Rice Research and Promotion Board estimates that the industry contributes more than $4 billion to state’s economy annually, and accounts for more than 25,000 jobs. Rice is the state’s second highest-valued commodity, and Arkansas’ top agricultural export.

**Industry Advocacy**

The Arkansas Rice Research and Promotion Board advocates for the interests of state rice growers. Its operating funds are raised through levies on the sale of grain. The Board funds industry promotional efforts at a state and national level through USA Rice. It also funds research activities at the University of Arkansas, including varietal development, research projects, on-farm trials, and Arkansas Foundation Seed program initiatives.

**Demand Segments**

Arkansas rice production commands a premium globally due to its strong quality perception. Key demand segments for Arkansas rice are the domestic long-grain market, long-grain import markets (e.g., Mexico, Haiti, and Canada), and domestic processors of medium-grain.

ENABLING ENVIRONMENT

STAKEHOLDERS

Arkansas Seed Council | Arkansas Seed Dealers Association | Arkansas State Plant Board | Rice Research Verification Program | USA Rice
Public Sector Funds Varietal Development and Subsidizes Foundation Seed Costs

**Seed System Structure**

- **Germplasm/Varieties**
- **Breeder Seed**
- **Foundation/Basic Seed**
- **Certified Seed/QDS**
- **Distribution**
- **Primary Production**
- **Distribution/Consumers**

**How financially self-sustaining?**
- Low: ≤ 1/3 of OpEx
- Medium: 2/3 x > 1/3 of OpEx
- High: ≥ 2/3 of OpEx

**Who does?**
- Public
- Private

**SEED**
- Varietal Development
- Cultivation
- Storage
- Consumption
- Own stocks
- Farmer exch.
- Market

**CERTIFIED SEED**
- demand forecasting and production planning

**Mature**
- Mostly Formal

**FOUNDATION SEED**
- demand forecasting and production planning

**Certified Seed/QDS**
- Mature
- Mostly Formal

**Breeder Seed**
- Demand forecasting and production planning

**Distribution**
- Primary
- Distribution/Consumers

**Context**
- Global Development
Summary of EGS System Success Factors

**Foundation Seed Costs Distributed Across Three Crops**
- Public Sector Funds University Research & Extension
- Foundation Seed Produced For Multiple Crops at a Near Cost Recovery Basis
- Commodity Association Provides Funding for University Research
- Farmer Cooperatives Provide Value Added Services & Even Out Cash Flows for Member-Farmers
- Seed Companies Promote Farmers’ Adoption of New Varieties

**Well-Organized Foundation Seed Preordering Program**
- Foundation Seed Production is Conservatively Managed to Mitigate Over-Production Risk
- Foundation Seed Scarcity Encourages Seed Producers to Pre-Order and Be A Consistent Buyer
- Ethical Co-opetition Among Seed Companies Increases Market Insight and Reduces the Risk of Building Inventory of Un-Preferred Varieties
- Public Sector Receives Input From the Private Sector on Grain Traits, Which Improves the Success of New Varieties
- Introduction of Hybrid Rice Put Pressure on Public Sector to Develop its Own Hybrid Rice Breeding Program

**Grower Support of Public Breeding Program**
- Farmer Trusted & Supported Research Program
- Farmer-Centered Approach to Extension
- Close Proximity & Collaboration Among Stakeholders
- Researchers Treat Farmers As Clients And Align Breeding Program Priorities to Meet Their Needs
- Seed Quality Assurance Agency is Helpful, And Not Viewed As A Policing Agency
## Financial Sustainability

<table>
<thead>
<tr>
<th>Key Success Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public Sector Funds</strong></td>
<td>University Research &amp; Extension&lt;br&gt;Research, varietal development, foundation seed production, and grower extension functions are sustained through public sector budget allocation and grants that fund operating costs and capital expenditures. Key operating costs that are funded by the public sector include researcher salaries and benefits, consumables, and facility upkeep (office, labs, acclimatized storage, fields).</td>
</tr>
<tr>
<td><strong>Foundation Seed</strong></td>
<td>Produced For Multiple Crops at a Near Cost Recovery Basis&lt;br&gt;The public sector leverages physical and human capital across three crops (rice, soybean, and wheat) to produce and sell foundation seed to certified seed growers. Foundation seed production at the University of Arkansas is professionally managed and respected by the industry. Foundation seed sales for rice are estimated to cover 70% of the Arkansas Foundation Seed program’s all-in seed production costs.</td>
</tr>
<tr>
<td><strong>Commodity Association</strong></td>
<td>Provides Funding for University Research&lt;br&gt;The Rice and Research Promotion Board commits half of its budget to support research rice research projects. Research funds are distributed through a competitive project application process in which extension and research scientists from the University of Arkansas and elsewhere submit project proposals to the Rice Research and Promotion Board for review and potential approval.</td>
</tr>
<tr>
<td><strong>Grower Cooperatives</strong></td>
<td>Provide Value Added Services &amp; Even Out Cash Flows for Grower-Members&lt;br&gt;Grower cooperatives have responded to the evolving needs of their grower-members. Cooperatives serve growers in commodity processing and marketing capacities and are tied directly into the commercial market. These ties to the market add tremendous value to growers as cooperatives can provide input on market needs directly to the growers and the breeding programs. They also add value for growers by leveraging their increased purchasing and buying power to reduce the cost of inputs and services, and to negotiate higher prices for farmer production. Other valued services that they provide to growers include quality control and financial liquidity through cash advances when the commodity is delivered to the mill, but has not yet been sold.</td>
</tr>
<tr>
<td><strong>Seed Companies</strong></td>
<td>Promote Growers’ Adoption of New Varieties&lt;br&gt;Seed companies play a critical role in increasing the adoption of new varieties. They pre-order foundation seed in Year 1, plant in Year 2, and sell in Year 3. The two-year lead time between the foundation seed order and the certified seed sale introduces significant demand risk that seed companies mitigate through trust-based relationships with their grower customers, sales &amp; marketing efforts (incl. varietal demonstration events for customers), and close relationships with breeders and researchers.</td>
</tr>
</tbody>
</table>
# Demand Planning and Operations

**Foundation Seed Production is Conservatively Managed to Mitigate Over-Production Risk**
The Arkansas Foundation Seed (AFS) program bases its foundation seed demand forecast on pre-orders, plus an estimate for in-season orders. To mitigate overage costs associated with holding inventory over for another season, demand forecasts are pragmatic. Demand for AFS produced foundation seed normally surpasses supply.

**Foundation Seed Scarcity Encourages Seed Growers to Pre-Order and Be Consistent Buyers**
Seed growers pre-order foundation seed because it is a necessary input of their business and stock-outs are expected. To manage scenarios where supply does not meet demand, customers can achieve *Priority Customer* standing through consistent early ordering of foundation seed, which gives them priority in getting their seed orders filled.

**Ethical Co-opetition Among Seed Companies Increases Market Insight and Reduces the Risk of Building Inventory of Un-Preferred Varieties**
Seed companies compete for certified seed sales, but have a shared interest in the growth of the Arkansas rice industry. They collaborate on issues of mutual importance and advocate for companies’ interests through the Arkansas Seed Dealers Association, which is led by seed company executives. Regional seed companies are critical enablers of the seed system, and rely on each other to execute their businesses. For example, when a seed company is short of seed, they reach out to other seed companies to satisfy their requirements. Cooperation between competitors also allows for enhanced coordination around product life cycles and demand planning. Communication between companies allows for phasing out of un-preferred varieties, as well as allocation of resources to ensuring adequate supplies of and support for new and existing varieties.

**Public Sector Receives Input From the Private Sector on Grain Traits, Which Improves the Success of New Varieties**
The public and private sectors collaborate to evaluate and screen research lines for traits that increase the profitability of commercial rice production (e.g., yield, stability, and disease tolerance). The public sector leverages private sector feedback on field performance trials and grain testing to increase the efficiency of its resource allocation, and improve the commercial adoption of new varieties.

**Introduction of Hybrid Rice Put Pressure on Public Sector to Develop its Own Hybrid Rice Breeding Program**
The introduction of hybrid rice in Arkansas by RiceTec in the early 2000s disrupted the rice seed industry. For many Arkansas rice farmers, the higher yield potential of hybrid rice seed was worth the increased seed costs compared to conventionally bred public varieties. The commercial success of hybrid rice, which is evidenced by its planting on approximately 40% of Arkansas rice acres in 2017, led Arkansas rice growers to fund a public hybrid rice breeding program at the Rice Research & Extension Center in order to develop lower cost, public sector alternatives. This is evidence of the pride, loyalty, and ownership that Arkansas growers have in and for the University of Arkansas breeding program.
Enabling Environment

**Grower Trusted & Supported Research Program**
Arkansas rice growers trust the Arkansas Rice Research and Extension program to deliver research findings and new varieties that improve the profitability of their operations. Growers have been planting Arkansas-released varieties for more than 100 years and have tremendous pride in the institution’s contribution to the development of the rice industry. Growers, through the Rice Research and Promotion Board, have been actively involved in guiding research priorities and disseminating information from the Arkansas Rice Research and Extension program.

**Grower-Centered Approach to Extension**
Qualified extension agents develop personal, trust-based relationships with growers who rely on their recommendations when making profit-impacting decisions including cultivar selection, planting timing, seeding rates, row spacing, irrigation, pesticide application, irrigation, drain timing, and harvest. Breeders, pathologists, entomologists, agricultural engineers, and agricultural economists at the Arkansas Rice Research and Extension program all act as a team to develop useful, timely information that allows growers to make well-informed decisions.

**Close Proximity & Collaboration Among Stakeholders**
Arkansas rice production is concentrated in the eastern counties of the state, which spans ~250 miles from north to south. The close proximity of actors, including breeders, researchers, agricultural extension officers, seed companies, seed certifiers, growers, grower cooperatives, and processors encourages the development of trust-based relationships and an intense focus on addressing the prioritized issues of a largely homogeneous agro-ecological environment.

**Researchers Treat Growers As Clients And Align Breeding Program Priorities to Meet Their Needs**
Rice researchers and growers have an interdependent relationship. Growers rely on researchers to develop new varieties, and researchers rely on growers to fund their research through grain levies. This symbiotic relationship promotes a strong feedback loop between stakeholders, who have a mutual interest in increasing the profitability of rice farming in Arkansas.

**Seed Quality Assurance Agency is Helpful, And Not Viewed As A Policing Agency**
The Arkansas State Plant Board is viewed as adding value to the system and not as a policing agency. Arkansas rice’s premium quality reputation is supported by the agency’s efforts to assure the quality of seed that is sold in the state. Stakeholders – especially breeders, seed companies, and growers – appreciate the role that the Arkansas Plant Board plays in protecting the industry.
### Financial Sustainability

The levies collected (check off funds), on the sale of the commodity have been flat for decades despite rising costs due to inflation. To overcome the widening funding gap, research administrators are allocating more of their time to identify alternative funding sources, which is time that could be better spent developing new varieties and supporting the breeding team.

### Demand Planning & Operations

Foundation seed orders made through the AFS require a 50% down payment at the time of the order. Seed growers’ cash flow constraints often lead them to under-order foundation seed due to this requirement. The net impact is that less foundation seed is produced than would be actually demanded by the market without the down payment requirement.

### Enabling Environment

A deep level of trust must exist between governments, extension agencies, and local growers for the system to function sustainably and successfully. A strong level of trust exists in the Arkansas rice industry, but it took several years and the cooperation of each and every market player to develop the trusting relationships that are the backbone of the model.
Key Events That Shaped the Evolution of the Arkansas Rice Seed System

Patterns begin to emerge
- Rice production begins in Arkansas and the first rice mills open
- Seed grower association is established to regulate seed production

Grow
- Duplication of & improvement of patterns
  - Increased number of rice mills in Arkansas alleviates shipping costs to mill in Louisiana
  - Arkansas Rice Council and University of Arkansas Foundation Seed Program is formed
  - Growers voluntarily contribute funds for research and promotion for ~30 years until Rice Research and Promotion Board is established

Improve
- Improvement leads to system equilibrium
  - Rice Research and Promotion Board is established and formalized the check-off system
  - University of Arkansas Division of Agriculture Extension Service established the Rice Research Verification Program to conduct on-farm demonstrations of research recommendations and new varieties

Stabilize
- Disequilibrium interrupts stabilized systems
  - Mandatory grower check-off is established by law for research and promotion
  - University of Arkansas Rice Breeding Program is the main supplier of new rice varieties and works hand-in-hand with the Foundation Seed Program to reach growers

Reinvent
- System responds by higher-level reinvention or descent to chaos
  - Increased production capacity at the new Foundation Seed Program facility ensures adequate supplies of non-hybrid varieties
  - The University of Arkansas breeding program increased communication with growers and industry to develop desirable varieties and keep interest in non-hybrid varieties

BIFURCATION POINT: INTRODUCTION OF HYBRID RICE IN 2005
Patterns begin to emerge
- Duplication of & improvement of patterns
- Improvement leads to system equilibrium
- Disequilibrium interrupts stabilized systems
- System responds by higher-level reinvention or descent to chaos

Descent into chaos
Introduction of Hybrid Rice in Arkansas by RiceTec in the 2000s Disrupted the Public Sector-Led Rice Seed Industry

Public Sector Foundation Rice Sales in Units (2013-2017)

Uncertainty
The value proposition of hybrid rice was compelling to growers, leading to rapid adoption and displacement of inbred, public sector varieties

Resilience
Growers, breeders, researchers, and the RREC responded with the introduction of improved varieties (i.e., LaKast, Diamond, and Titan) and the establishment of a public hybrid rice breeding program

# Arkansas Rice EGS System Timeline

<table>
<thead>
<tr>
<th>Period</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1900-1979</strong></td>
<td></td>
</tr>
<tr>
<td>1950-</td>
<td>Arkansas Rice Council formed what was to become the Rice Research &amp; Promotion Board (RRPB). Rice growers voluntarily contributed funds to promote the rice industry</td>
</tr>
<tr>
<td>1973-</td>
<td>Rice growers voluntarily contribute check off funds specifically for rice variety research, but not in an organized fashion until RRPB is established</td>
</tr>
<tr>
<td>1906-</td>
<td>First Arkansas rice mill opens in Stuttgart, AR. Four more mills added by 1910. Reduced grower shipping costs to Louisiana mills.</td>
</tr>
<tr>
<td>1950-</td>
<td>Flood Control Act enacted by congress to provide rice irrigation from White River following concerns about drought and depletion of the Grand Prairie water table</td>
</tr>
<tr>
<td>1951-</td>
<td>U. of AR Foundation Seed Program est. due to support from wheat and rice breeding programs</td>
</tr>
<tr>
<td>1955-</td>
<td>Governmental acreage controls stabilized rice production to 500,000 acres</td>
</tr>
<tr>
<td>1974-</td>
<td>Rice marketing quotas lifted and rice acreage increased throughout Arkansas</td>
</tr>
<tr>
<td>1917-</td>
<td>AR Seed Growers Association est.</td>
</tr>
<tr>
<td>1919-</td>
<td>International Crop Improvement Association established (name later changed to Association of Official Seed Certification Agencies)</td>
</tr>
<tr>
<td>1921-</td>
<td>AR Rice Growers Coop established to combat low rice prices following WWI. This coop eventually became Riceland Foods, Arkansas’ first coop and mill</td>
</tr>
<tr>
<td>1925-</td>
<td>University of AR Rice Research and Extension Center est. joint program between USDA and U. of AR</td>
</tr>
<tr>
<td>1931-</td>
<td>AR Plant Board designated by AR legislature as seed certification agency for Arkansas. Official Standards for Seed Certification established (circular 15)</td>
</tr>
<tr>
<td>1950-</td>
<td>Arkansas Rice Council est.</td>
</tr>
<tr>
<td>1970-</td>
<td>Shifting of crop acres from pasture to row crops due to increased global market demand (wheat) and better variety availability</td>
</tr>
<tr>
<td><strong>1980-1999</strong></td>
<td></td>
</tr>
<tr>
<td>1980-</td>
<td>University of Arkansas rice breeding program was established due to funding from the Rice Research and Promotion Board</td>
</tr>
<tr>
<td>1983-</td>
<td>University of AR Division of Agriculture Cooperative Extension Service est. Rice Research Verification Program</td>
</tr>
<tr>
<td>1998-</td>
<td>Dale Bumpers National Rice Research Center est. in Stuttgart, AR</td>
</tr>
<tr>
<td>1985-</td>
<td>AR Rice Research and Promotion Board est. and begins formal Rice Checkoff program under Act 725, combining the efforts of the promotion and research voluntary grower funds</td>
</tr>
<tr>
<td>1987-</td>
<td>Increase of refundable rate to 3 cents per bushel from original 2 cents</td>
</tr>
<tr>
<td>1999-</td>
<td>Act 16 est. mandatory assessment that is in place today of 1.35 cents/bushel producers and first buyers</td>
</tr>
<tr>
<td><strong>2000-Present</strong></td>
<td></td>
</tr>
<tr>
<td>2016-</td>
<td>Emergency tariff rate quota funds allocated to Rice Research and Extension Center from USA Rice to supplement low check-off dollars for developing high nighttime temp varieties</td>
</tr>
<tr>
<td>2005-</td>
<td>RiceTec releases first hybrid rice varieties</td>
</tr>
<tr>
<td>2016-</td>
<td>New, improved AR Foundation Seed facility opened in Stuttgart, AR</td>
</tr>
<tr>
<td>2005-</td>
<td>Continued demand for rice and wheat varieties; and new demand for soybean varieties</td>
</tr>
<tr>
<td>2016-</td>
<td>Continued demand for herbicide resistant, non-hybrid varieties bolsters need for breeding program</td>
</tr>
<tr>
<td>2016-</td>
<td>Continued funding from private, governmental, NGO organizations, and licensing and royalty fees for agricultural research</td>
</tr>
</tbody>
</table>

**Timeline Notes:**
- **1931-** Rice growers voluntarily contribute check off funds specifically for rice variety research, but not in an organized fashion until RRPB is established.
- **1950-** Flood Control Act enacted by congress to provide rice irrigation from White River following concerns about drought and depletion of the Grand Prairie water table.
- **1951-** U. of AR Foundation Seed Program est. due to support from wheat and rice breeding programs.
- **1955-** Governmental acreage controls stabilized rice production to 500,000 acres.
- **1970-** Shifting of crop acres from pasture to row crops due to increased global market demand (wheat) and better variety availability.
Arkansas Rice EGS System Timeline Key
Takeaways

• University of Arkansas’ Foundation Seed Program was not developed in a one-crop vacuum. The rice and wheat industries were both instrumental in funding the beginning stages of the program as growers desired to regulate their seed inputs following WWII. The soybean industry’s success in later years helped to further advance the Foundation Seed Program, including the ability to build new and improved seed facilities as costs were shared across the three crops.

• Grower desire for a quality seed supply and improved varieties predates the required checkoff programs started in 1985. For several years prior, growers voluntarily contributed to funds that were directed toward industry promotion and later on, specifically toward the research of new rice varieties. Grower willingness to pay out of their own profits was a key factor in the success of the breeding program and overall rice industry growth. These two voluntary funding groups eventually merged to become the AR Rice Research and Promotion Board, which is still in place today. Grower interest in serving in leadership and committee roles were the key to these organizations’ successes throughout the history of the industry.

• Establishment of rice mills in close proximity to Arkansas rice growers reduced shipping costs and transportation time lags, improving market access for growers. These mills proved to be so important to industry growth that five mills were established in Arkansas over the span of 4 years (1906-1910).
Market Dynamics
Arkansas is the Rice Production Leader in the US

The U.S. Ranked 11th Globally for Total Rice Production in 2016

<table>
<thead>
<tr>
<th>#Country</th>
<th>2016 Production Total (tons)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 China (incl. Taiwan)</td>
<td>232,199,894</td>
<td>28%</td>
</tr>
<tr>
<td>2 India</td>
<td>174,632,558</td>
<td>21%</td>
</tr>
<tr>
<td>3 Indonesia</td>
<td>85,027,260</td>
<td>10%</td>
</tr>
<tr>
<td>4 Bangladesh</td>
<td>57,849,000</td>
<td>7%</td>
</tr>
<tr>
<td>5 Vietnam</td>
<td>47,780,952</td>
<td>6%</td>
</tr>
<tr>
<td>6 Myanmar</td>
<td>28,240,115</td>
<td>3%</td>
</tr>
<tr>
<td>7 Thailand</td>
<td>27,794,275</td>
<td>3%</td>
</tr>
<tr>
<td>8 Philippines</td>
<td>19,389,970</td>
<td>2%</td>
</tr>
<tr>
<td>9 Brazil</td>
<td>11,684,408</td>
<td>1%</td>
</tr>
<tr>
<td>10 Pakistan</td>
<td>11,453,371</td>
<td>1%</td>
</tr>
<tr>
<td>11 United States of America</td>
<td>11,183,755</td>
<td>1%</td>
</tr>
<tr>
<td>12 Others</td>
<td>109,568,586</td>
<td>13%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>816,804,143</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

SOURCE: FAO STAT

Asian countries account for about 90% of total world rice production

The majority of rice production in the US is long-grain varieties (~75%), followed by medium-grain varieties (~24%)

Arkansas leads the US in long-grain rice production, while California dominates in medium- and short-grain rice production

SOURCE: USDA ERS, USDA Rice Overview
Arkansas rice production is concentrated in the eastern counties of the state, which spans ~250 miles from north to south. The close proximity of actors, including breeders, researchers, agricultural extension officers, seed companies, seed certifiers, growers, grower cooperatives, and processors encourages the development of trust-based relationships, and an intense focus on addressing the prioritized issues of a largely homogeneous agro-ecological environment.

Arkansas farmers grow long-grain and medium-grain rice

Over 70% of Arkansas rice production is long-grain

Medium-grain rice is produced to meet processor demand

Source: USDA NASS
Arkansas Rice Grower Profile

In 2017, Arkansas growers produced 239,254,400 bushels of rice on 1.521 million acres. Rice is the state’s second highest-valued commodity (behind cotton), and Arkansas’ top agricultural export.

Demographics

- Farms: 2,500
- Production Acres\(^1\): 1,521,000
- Average Farm Size: 608 Acres/Per

Economic Impact

The rice industry contributes more than $4 billion to Arkansas’ economy annually, and accounts for more than 25,000 jobs.

SOURCE: Arkansas Farm Bureau-2017 Arkansas Rice Promotion Program
(1) University of Arkansas Extension-2017 Arkansas Rice Quick Facts

#ArFBFarmFact
Harvested Acres and Yields Have Increased Over Time

AR Rice Harvested Acres & Yields (Bushel/Acre) 1986 to 2016

Percentage of AR Rice Acres Planted With Hybrid Rice

Hybrid rice adoption has leveled since exceeding 50% of planted rice acres in 2012

SOURCE: History of Arkansas Rice Acreage and Yield
Consumer Preference Informs Rice Production Systems By Region

Over 50% of US Rice Production is Exported

- Mexico has consistently been the largest export market (20.5% in 2016)
- Central & South American countries represent over 50% of the export market
- Export volumes fluctuated within a 1,000 ton range between 2008 and 2016
Leadership
University Breeding Program Enables the Seed System

**VARIETAL DEVELOPMENT & SEED DEPLOYMENT**

**Varietal Development**
Varietal development for Arkansas rice is conducted through the University of Arkansas System’s Division of Agriculture and is supported by check off funds collected by the Arkansas Rice Research and Promotion Board, as well as through grant funding and other state and federal funding sources.

**Seed Multiplication**
All breeder and foundation seed multiplication occur as part of the Arkansas Foundation Seed Program at the Rice Research & Extension Center (RREC). The Foundation Seed Program also works closely with the Arkansas Division of Agriculture’s Crop Variety Improvement Program when increasing new varieties.

**Certified Seed Production**
Certified seed production is performed by ~60 commercial seed growers that purchase foundation seed from the Arkansas Foundation Seed Program. These growers are members of the Arkansas Seed Growers Association and their seed is sold by members of the Arkansas Seed Dealers Association, which provides advocacy, coordination, and regulatory functions for seed production.

**FARMER PRODUCTION, MARKETING, AND KEY DEMAND SEGMENTS**

**Farm Production**
There are more than 2,500 rice farms in the state of Arkansas, and 96% of them are family owned. In 2017, over 1.5 million acres of rice were farmed in the state. The Arkansas Rice Research and Promotion Board estimates that the industry contributes more than $4 billion to state’s economy annually, and accounts for more than 25,000 jobs. Rice is the state’s second highest-valued commodity, and Arkansas’ top agricultural export.

**Industry Advocacy**
The Arkansas Rice Research and Promotion Board advocates for the interests of state rice growers. Its operating funds are raised through levies on the sale of grain. The Board funds industry promotional efforts at a state and national level through USA Rice. It also funds research activities at the University of Arkansas, including varietal development, research projects, on-farm trials, and Arkansas Foundation Seed program initiatives.

**Demand Segments**
Arkansas rice production commands a premium globally due to its strong quality perception. Key demand segments for Arkansas rice are the domestic long-grain market, long-grain import markets (e.g., Mexico, Haiti, and Canada), and domestic processors of medium-grain.

**ENABLING ENVIRONMENT & STAKEHOLDERS**
Arkansas Seed Council | Arkansas Seed Dealers Association | Arkansas State Plant Board | Rice Research Verification Program | USA Rice
Organizational Leadership by Value-Chain Step

- **Breeder**
  - AR Rice Research and Extension Center (RREC)

- **Foundation**
  - The Arkansas Foundation Seed Program (AFS)

- **Certified**
  - Arkansas Seed Growers and Dealers

- **Commercial**
  - Arkansas Rice Growers

**Regional Testing**
- (Universities in MS, AR, LA, TX), 
- & Grain Testing (Riceland)

**Certified Seed Growers**
- (Arkansas Seed Growers and Dealers Associations)

**Seed Certification**
- (Arkansas State Plant Board)

**Check-Off Fund Collection**
- (AR Rice Research and Promotion Board)
# Organizational Value Chain Leadership Summary

<table>
<thead>
<tr>
<th>Organization</th>
<th>Value Chain Role</th>
<th>Major Funding Sources</th>
<th>Financial Sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice Research and Extension Center</td>
<td>• Varietal Development • On-farm demonstration of research recommendations</td>
<td>• State Funding • Grants • Arkansas Rice Research &amp; Promotion Board</td>
<td>Subsidized by the Public &amp; Private Sector</td>
</tr>
<tr>
<td>Rice Research Verification Program</td>
<td></td>
<td>• State Funding • Arkansas Rice Research &amp; Promotion Board supports special projects</td>
<td>Partially Subsidized</td>
</tr>
<tr>
<td>Arkansas Foundation Seed program</td>
<td>• Varietal licensing • Foundation seed production, storage, delivery, and sale</td>
<td>• Foundation seed sales • Arkansas Rice Research &amp; Promotion Board</td>
<td>Financially Sustainable</td>
</tr>
<tr>
<td>Arkansas Seed Growers Association</td>
<td>• Seed grower advocacy, coordination, and oversight</td>
<td>• Membership dues • Members profit from production of certified seed for seed dealers</td>
<td>Financially Sustainable</td>
</tr>
<tr>
<td>Arkansas Seed Dealers Association</td>
<td></td>
<td>• Seed producer membership dues • Members profit from the sale of certified seed</td>
<td>Financially Sustainable</td>
</tr>
<tr>
<td>Arkansas State Plant Board</td>
<td></td>
<td>• Certification of foundation and commercial seed</td>
<td>Financially Sustainable</td>
</tr>
<tr>
<td>Grower Cooperatives</td>
<td>• Aggregate, store, mill, and market members’ grain production to improve farmer value capture</td>
<td>• Cost-recovery through service provision (ex. milling and storage)</td>
<td>Financially Sustainable</td>
</tr>
<tr>
<td>Arkansas Rice Research &amp; Promotion Board</td>
<td>• Advocate for the interests of Arkansas rice growers</td>
<td>• Assessments on the sale and purchase of grain (more commonly known as a: commodity checkoff program)</td>
<td>Financially Sustainable</td>
</tr>
</tbody>
</table>
Rice Research and Extension Center

Mission:
“Improve rice production for Arkansas farmers through applied research and extension programs to develop sustainable systems that protect our natural resources, enhance the economy of Arkansas and provide a food product consumed worldwide.”

Program Details:
The programs that originate at RREC have resulted in the development of 40+ improved rice varieties, coupled with crop management recommendations, that are variety specific, are sustainable, and ensure the overall success of the variety when it is produced by Arkansas rice farmers.

New variety and crop management recommendations are communicated to Arkansas rice growers through field days, grower meetings, fact sheets, and newsletters. New communication technology has been incorporated so that information can be obtained through the internet, social media (Facebook and twitter), and e-mail.

The RREC features 1,000 acres of research capacities near Stuttgart, AR. It is home to research labs, seed cold storage facilities, state-of-the-art breeding equipment, research fields, and meeting facilities that members of the Arkansas rice community use to connect throughout the year. Extension agents, through the RREC, hold Rice College every other year to educate growers about new varieties, water quality, mechanization, and fertility, among many other topics.

Funding Sources:
- State Funding
- Grants
- Arkansas Rice Research & Promotion Board

Staffing:
An interdisciplinary approach to breeding and variety release is made possible by staffing rice breeders, plant pathologists, entomologists, engineers, and economists at the RREC. There are currently twelve scientists dedicated to improving rice varieties at the RREC.

“We house all relevant disciplines in the faculty here at the station, permitting us to be housed right in the heart of the rice-growing region of the state, performing our work...that's unique to this location.” – Jarrod Hardke, Extension Agronomist
The RRVP is an interdisciplinary effort between growers, county extension agents, extension specialists, and researchers. The RRVP is an on-farm demonstration of all the research-based recommendations developed by the University of Arkansas Division Of Agriculture for the purpose of increasing the profitability of rice production in Arkansas.

**Program Details & Objectives:**

- The RRVP was established in 1983 as a public exhibition of the implementation of research-based Extension recommendations in a field-scale farming environment on released AR rice varieties. More than 460 rice fields have been enrolled in the RRVP since 1983.

**Program Objectives:**

1. Demonstrate and verify research-based recommendations on Arkansas rice varieties on Arkansas farms
2. Develop a database for economic analysis of all rice production aspects
3. Demonstrate benefits of available technology and inputs for higher commercial rice yields
4. Promote timely implementation of rice management practices among growers
5. Provide training and assistance to county agents and growers with limited rice production experience

Through the RRVP, growers receive field consultations and research-based growing guidelines from extension agents to follow for a minimum of two growing seasons. Growers collect field data throughout the two growing seasons and report the results back to the program. These results, along with the growing guidelines connected with them, are published by the University of Arkansas Division of Agriculture for all farmers to reference. Growers who participate in this program are given the freedom to choose their own varieties for growing and are permitted to keep the grain that they grow, but incur all production costs. Two technical support (verification scientists), oversee 7-10 farms each and are overseen by the extension rice agronomist.

**Impact:**

- Enables on-farm verification of AR released varieties under recommended conditions with published data and growing information made available to growers, at no cost, to improve their growing practices
- Increased yields per acre from following RRVP guidelines: average yield per acre in RRVP 2011-2015: 182 bushels/acre, whereas the state average for all AR growers for the same time period was 163 bushels/acre

**RRVP Presence in Arkansas:**

In 2016, farms in 15 counties throughout Arkansas were enrolled in the RRVP, representing an average field size of 54 acres.
“The primary goal of AFS is to make seed of newly released and proven varieties available to all Arkansas growers as quickly as possible. It is felt that foundation-grade seed should be placed in the grower’s hands who are most assured of maximum production and who are most likely to maintain the seed within the Seed Certification Program standards.”

“The Arkansas Foundation Seed (AFS) Program, based at the Rice Research and Extension Center near Stuttgart, will be responsible for the production of foundation seed and assisting breeders in the production of breeder’s seed, as requested, and/or where required by a contract or license agreement managed by the University of Arkansas System Division of Agriculture Crop Variety Improvement Program.”

“When plant materials are licensed or managed under an agreement, AFS works closely with the Crop Variety Improvement Program. The two entities, along with a lead University of Arkansas System Division of Agriculture Extension Specialist, work to coordinate seed for county and regional field tests, manages the increase and distribution of foundation seed stock and handles revenues from seed sales and non-licensed products.”

“The Arkansas Seed Council is an eleven-member advisory group whose sole function is to assist in the allocation of foundation-grade seed produced by the Arkansas Agricultural Experiment Station. The Seed Council approves requests for foundation seed based on the applicants experience, equipment and known ability as a seed producer.”
Arkansas Seed Growers Association and Arkansas Seed Dealers Association

---Arkansas Seed Growers Association---

This 100-year-old organization is the oldest farm organization still in operation in Arkansas. It is described by members as a “family organization” that connects rice growers with seed growers, providing them with more options when purchasing seed.

The Association assists the Arkansas rice industry through having a voice in foundation seed allotment, promoting Arkansas agriculture alongside the University of Arkansas, supporting legislation, and providing grower education during Association meetings, where growers receive updates from University breeders and researchers on new varieties, a State Plant Board Update, and other pertinent topics.

---Arkansas Seed Dealers Association---

Objectives:
- Foster, promote improve and protect the seed industry and its allied branches
- Encourage and promote a united effort for increasing the purity and improving the quality of all seeds sold
- Aid in maintaining high standards of quality of seeds and encourage the observance and use of such standards by all members
- Promote firmer business relations between all those engaged in the rice trade everywhere and manage trade differences and disputes arising between members, or between members and non-members

Funding Sources
- Seed producer annual membership dues ($275)

Association Details
- Holds annual Summer and Winter Conventions
- Members must apply for a Seed Dealer’s License through the Arkansas State Plant Board

---Funding Sources---

- Membership dues
- Seed producer annual membership dues ($275)

---Association Details---

- Holds annual Summer and Winter Conventions
- Members must apply for a Seed Dealer’s License through the Arkansas State Plant Board

How these organizations work together:

- Seed growers order foundation seed from RREC
- Seed dealers contract production of certified seed from seed growers at a premium to grain prices
- AR Plant Board inspects certified seed grower fields and issues seed certification tags
- Seed growers deliver certified seed to seed dealers (seed companies)
- Seed dealers sell certified seed to rice growers

SOURCE: Arkansas Seed Dealers Association
Delta Farm Press: 100 Year Anniversary of Arkansas Seed Growers Association
Arkansas State Plant Board

**Mission:**

“The mission of the Arkansas State Plant Board is to protect and serve the citizens of Arkansas and the agricultural and business communities by providing information and unbiased enforcement of laws and regulations thus ensuring quality products and services.”

**Program Details:**

The Seed Division’s responsibilities are both regulatory and service based: All activities are coordinated through the Division Director.

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Regulatory:</strong> Serves to protect the consumer from poor quality or mislabeled planting seed and to provide a level opportunity for the selling of seed through field inspections in areas where agricultural seed is sold, regulation compliance checks, and sampling of seed being sold. Field inspectors ensure that all the seed being offered for sale has a certification label.</td>
</tr>
<tr>
<td>2</td>
<td><strong>Seed Certification / Quality Assurance - Identity Preserved:</strong> As the Official Seed Certifying Agency for Arkansas, the Seed Certification Program provides constant supervision to the production of seed with the highest genetic and mechanical purity. Rigid standards of quality are set-up by the Plant Board for the three classes of certified seed. Detailed records are maintained for four generations of seed production. Each generation must be field inspected and then laboratory tested. Only when all standards are met can certified tags/labels be issued. The Quality Assurance / Identity Preserved program offers third-party unbiased inspections for seedsmen. An individual program is designed to meet the needs of each participating company and fees are assigned according to the type of services needed.</td>
</tr>
<tr>
<td>3</td>
<td><strong>Official Arkansas Seed Laboratory:</strong> The seed laboratory tests both regulatory samples from field and seed compliance tests, and service samples, which are seed samples submitted by seedsmen or farmers for the purpose of obtaining information about seed quality for planting purposes.</td>
</tr>
</tbody>
</table>

**Funding Source**

Seed certification charges

The State Plant Board divides the state into 4 districts, each with their own supervisor and inspectors. In total, there are ~40 certified seed growers registered with the Plant Board.
Grower Milling Co-Operatives

"Grower cooperatives help us create more value for the rice industry than we ever could individually." –Michael Smith, Riceland Foods

<table>
<thead>
<tr>
<th>Cooperatives Create Value for Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Co-Operative Financing</strong></td>
</tr>
<tr>
<td>• Founded in 1921</td>
</tr>
<tr>
<td>• All rice is produced in the United States</td>
</tr>
<tr>
<td>• Grower-owned cooperative with 5,500 members who are also Riceland’s stockholders and growers</td>
</tr>
<tr>
<td>• Operates 20 grain elevators in Arkansas</td>
</tr>
<tr>
<td>• Provides grain testing for University of Arkansas rice varieties</td>
</tr>
<tr>
<td>• Offers products for retail, industrial, institutional food service, animal feed, and pet food industries</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cooperatives Service Offerings Have Evolved To Meet Grower Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>The services that cooperatives offer their grower-owners has evolved with the industry. When growers needed seeds, cooperatives stepped in to provide them. When growers wanted independent grain testing capabilities, cooperatives resourced laboratories.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value Addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperatives are a key factor in unsticking the bottlenecks that inhibit grower value capture by offering commodity processing services like milling, grain storage, marketing, value-addition through new product development, contracted production, and by providing industry-specific research to breeding programs.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cooperatives help alleviate growers’ cash flow uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperatives offer growers options for financing throughout the growing year. Growers can choose a pooling option, where they receive a payment advance of ~75% during the growing year, as well as a final advance at the end of the year, allowing for a spreading out of cash flow instead of one lump sum at the end of production. Growers can also opt to enter a voluntary marketing program, where they deliver grain just once a year. The flexibility of payment options assists the grower in managing expenses over a longer term.</td>
</tr>
</tbody>
</table>
Arkansas Rice Research and Promotion Board

Mission:
“The Arkansas Rice Research and Promotion Board (RRPB), was established in 1985 to improve the profitability of growing rice in Arkansas by conducting a program of research, extension, and market development.”

Program Details:
Under the check-off program, rice growers contribute 1.35 cents per bushel for rice research and the first buyer of rice contributes 1.35 cents per bushel for promotion and market development efforts.

The program provides approximately $2.5 million to $3 million annually for research efforts conducted by the University of Arkansas System Division of Agriculture.

This check-off money funds research at the RREC and pays salaries at the Rice Research Verification Program, and enables the publication of grower education materials.

Research projects at the University of Arkansas are reviewed annually by the RRPB and new proposals are considered each year. The USA Rice Council has been chosen as the main representative of the Arkansas rice industry in the global marketplace.

Additional Funding:
In 2016, tariff rate quota (TRQ) funds were allocated to the RREC by the Rice Research and Promotion Board to benefit the rice breeding program, as well as several other programs. TRQ funds are intended for use as one-time emergency research funds. The 2016 allotment will be used by the RREC to supplement check-off research dollars in developing varieties tolerant to high nighttime temperatures that decreased 2016 rice yields. The RRPB is a key leadership organization that has proven its loyalty and dedication to meeting grower needs.

RRPB Leadership Structure
The Arkansas Rice Research and Promotion Board consists of nine rice growers nominated by industry organizations and appointed by the governor.
Stakeholders Collaborate for the Good of the Industry

Arkansas Rice Expo - Home Grown, World Famous

Aug 04, 2017
STUTTGART, AR -- The University of Arkansas held its annual rice expo and field day here today, and USA Rice staff joined several hundred rice farmers and industry members to highlight research, discuss industry issues, and to celebrate everything rice just before harvest begins in the area.

In addition to field tours, the expo featured a trade show and research seminars showcasing the latest rice products and varieties. The keynote address was delivered by former U.S. Congressman Charlie Stenholm of Texas who discussed the many challenges in passing a new farm bill and balancing the federal budget.

The Arkansas Rice Research and Promotion Board also met yesterday, and USA Rice President & CEO Betsy Ward provided updates on USA Rice domestic and international activities, and talked about some of the new players in key positions in Washington, DC.

“The expo had a great turnout this year,” said Arkansas Rice Federation Chairman Jeff Rutledge. “This speaks volumes about the quality of the programming and research done by the University of Arkansas.”
Research & Varietal Development
Breeding Program Details

“In rice breeding, improved quality is just as important as increased yield.” – Karen Moldenhauer, UA Rice Breeder

Breeding Goals

- Increased yield potential
- Increased quality: low chalk, acceptable cooking qualities, nighttime temperature resistance
- Improved processing characteristics
- Disease resistance
- Earliness
- Strong straw

UA Rice Breeding Program Quick Stats

- Established in the 1930s
- Developed 40+ improved rice varieties
- Partnership with AR Rice Research and Promotion Board since 1980
- Program includes breeding for medium grain, long grain, hybrid grain varieties
- 1,000 acre breeding facility is located in Stuttgart, AR
- 30% of rice grown in Arkansas developed by the UA breeding program

Partnerships Fuel the Breeding Program’s Success

<table>
<thead>
<tr>
<th>Industry</th>
<th>Partnerships Fuel the Breeding Program’s Success</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Riceland Grain Testing Partnership allows for data collection based on milling and marketability during varietal development</td>
</tr>
<tr>
<td></td>
<td>• Kellogg’s Approved Varieties List sends a signal to growers about which varieties to order from the RREC, based on industry demand</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Growers</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rice Research Verification Program assists growers in implementing best practices withUA varieties and provides verification of varieties to other growers of UA variety efficacy. This program allows for grower training, which increases the success of UA varieties in the market</td>
</tr>
<tr>
<td>• DD50 Computerized Rice Management Program assists growers with 26 management decisions based on growth stage (herbicide application, critical timing for insect and disease spraying, and N application). DD50 provides growers with valuable information to successfully grow new UA varieties. Growers feed information to the DD50 program, allowing breeders to continue to collect and update data on released varieties grown under on-farm conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Breeders, agronomists, pathologists, entomologists, ag engineers, ag economists at UA work together for the successful release of new UA varieties and the development of sustainable production practices. Extension is the key to sustainably and effectively communicating research information at the farm level</td>
</tr>
</tbody>
</table>
## Stage Gate Process – Breeding to Seed Deployment

8-year breeding process from cross to release:

<table>
<thead>
<tr>
<th>Breeding Phase</th>
<th>Varietal Testing Stage</th>
<th>Details</th>
<th>Location of Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1-2</td>
<td>Genetic Crossing</td>
<td></td>
<td>RREC in Stuttgart, AR</td>
</tr>
<tr>
<td></td>
<td>(F1 &amp; F2)</td>
<td></td>
<td>and three on-farm locations</td>
</tr>
<tr>
<td>Year 2-4</td>
<td>Selections</td>
<td>Continuous selections occur throughout the entire breeding timeline</td>
<td>Richeland in Stuttgart, AR &amp; 2-3 research farm sites</td>
</tr>
<tr>
<td></td>
<td>(F3 &amp; F4 selections of trialed varieties kept each year)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 4-8</td>
<td>Seed increases</td>
<td>Conducted by RREC breeding program. From here, lines may advance to regional trials for comparison against commercially released lines</td>
<td>Uniform Regional Rice Nursery (AR, LA, MS, MO, TX)</td>
</tr>
<tr>
<td></td>
<td>(Breeder to Foundation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variety Trials</td>
<td>Lines are tested in 5 states after advancing through AR Performance Trials</td>
<td>RREC in Stuttgart, AR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 9</td>
<td>Foundation Seed Available to Certified Seed Companies and Growers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Conversations with AR Rice Breeding Program, University of Arkansas-RREC Informational Video.
# Seed Multiplication Timeline

## 5-year process from Breeder Seed to Commercial Seed:

### Multiplication Phase

<table>
<thead>
<tr>
<th>Year</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 4</td>
<td>Increasing Selections (40lbs of seed)</td>
</tr>
<tr>
<td>Year 5</td>
<td>Multiplication Year One</td>
</tr>
<tr>
<td>Year 6</td>
<td>Multiplication Year Two</td>
</tr>
<tr>
<td>Year 7</td>
<td>Foundation Seed (Multiplication Year Three)</td>
</tr>
<tr>
<td>Year 8</td>
<td>Certified Seed</td>
</tr>
<tr>
<td>Year 9</td>
<td>Production and Distribution of Commercial Seed</td>
</tr>
</tbody>
</table>

### Breeder Seed to Foundation Seed Process:

- **HEAD ROWS** produced by RREC breeder team in year one
- Head rows **PLANTED** to produce seed for foundation program increases in year two
- **FOUNDATION SEED** produced in year three

This is a continuous process: Head row planting continues even after a variety is released to ensure clean seed is available each season.

Source: Conversations with AR Rice Breeding Program, University of Arkansas-RREC Informational Video
Diamond rice is a very high yielding, very short-season, long-grain rice developed at the Division of Agriculture’s Rice Research and Extension Center in Stuttgart, Arkansas. Diamond is close in maturity to Lakast™ and about 4 to 5 days earlier than the Roy J varietal. Diamond has straw strength of 3 (equal to Wells), compared to a 4 for LaKast and 1 for Roy J. Diamond is 104 cm in plant height which is similar to Roy J and Wells. Rough rice grain yields of Diamond have consistently ranked as one of the highest in the Arkansas Rice Performance Trials.

Diamond is rated S to sheath blight, blast, stem rot and kernel smut, which compares to Francis, Roy J, and Wells. Diamond is rated MS to bacterial panicle blight and lodging and VS to false smut using the standard disease R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible and VS = very susceptible to disease. Plants of Diamond have erect culms, green erect leaves, and glabrous lemma, palea, and leaf blades. The lemma and palea are straw colored with purple apiculi, many of which fade to straw at maturity.

The endosperm of Diamond is non-glutinous, non-aromatic, and covered by a light brown pericarp. Milled kernels of Diamond are long at 7.15 mm compared to Lakast, Roy J, Wells, Taggart and Mermentau at 7.47, 7.24, 7.16, 7.40 and 7.06 mm, respectively. Rice quality parameters indicate that Diamond has typical southern U.S. long-grain rice cooking quality. Diamond has an average apparent starch amylose content of 22.8 g kg\(^{-1}\) and an intermediate gelatinization temperature (70 - 75 degrees C), as indicated by an average alkali spreading reaction of 3 to 5.
Demand Planning and Operations
### Demand Planning and Operations

<table>
<thead>
<tr>
<th>Key Success Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Foundation Seed Production is Conservatively Managed to Mitigate Over-Production Risk</strong></td>
<td>The Arkansas Foundation Seed (AFS) program bases its foundation seed demand forecast on pre-orders, plus an estimate for in-season orders. To mitigate overage costs associated with holding inventory over for another season, demand forecasts are pragmatic. Demand for AFS produced foundation seed normally surpasses supply.</td>
</tr>
<tr>
<td><strong>Foundation Seed Scarcity Encourages Seed Growers to Pre-Order and Be Consistent Buyers</strong></td>
<td>Seed growers pre-order foundation seed because it is a necessary input of their business and stock-outs are expected. To manage scenarios where supply does not meet demand, customers can achieve Priority Customer standing through consistent early ordering of foundation seed, which gives them priority in getting their seed orders filled.</td>
</tr>
<tr>
<td><strong>Ethical Co-opition Among Seed Companies Increases Market Insight and Reduces the Risk of Building Inventory of Un-Preferred Varieties</strong></td>
<td>Seed companies compete for certified seed sales, but have a shared interest in the growth of the Arkansas rice industry. They collaborate on issues of mutual importance and advocate for companies’ interests through the Arkansas Seed Dealers Association, which is led by seed company executives. Regional seed companies are critical enablers of the seed system, and rely on each other to execute their businesses. For example, when a seed company is short of seed, they reach out to other seed companies to satisfy their requirements. Cooperation between competitors also allows for enhanced coordination around product life cycles and demand planning. Communication between companies allows for phasing out of un-preferred varieties, as well as allocation of resources to ensuring adequate supplies of and support for new and existing varieties.</td>
</tr>
<tr>
<td><strong>Public Sector Receives Input From the Private Sector on Grain Traits, Which Improves the Success of New Varieties</strong></td>
<td>The public and private sectors collaborate to evaluate and screen research lines for traits that increase the profitability of commercial rice production (e.g., yield, stability, and disease tolerance). The public sector leverages private sector feedback on field performance trials and grain testing to increase the efficiency of its resource allocation, and improve the commercial adoption of new varieties.</td>
</tr>
<tr>
<td><strong>Introduction of Hybrid Rice Put Pressure on Public Sector to Develop its Own Hybrid Rice Breeding Program</strong></td>
<td>The introduction of hybrid rice in Arkansas by RiceTec in the early 2000s disrupted the rice seed industry. For many Arkansas rice farmers, the higher yield potential of hybrid rice seed was worth the increased seed costs compared to conventionally bred public varieties. The commercial success of hybrid rice, which is evidenced by its planting on approximately 40% of Arkansas rice acres in 2017, led Arkansas rice growers to fund a public hybrid rice breeding program at the Rice Research &amp; Extension Center in order to develop lower cost, public sector alternatives. This is evidence of the pride, loyalty, and ownership that Arkansas growers have in and for the University of Arkansas breeding program.</td>
</tr>
</tbody>
</table>
Early Generation Seed Deployment Model

<table>
<thead>
<tr>
<th>Breeder Seed</th>
<th>Foundation Seed</th>
<th>Certified Seed</th>
<th>Commercialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who</td>
<td>UA Division of Agriculture</td>
<td>UA Division of Agriculture</td>
<td>Independent Growers on Contract Basis with Certified Seed Companies</td>
</tr>
<tr>
<td>Sector</td>
<td>Public</td>
<td>Public</td>
<td>Private</td>
</tr>
<tr>
<td>Input</td>
<td>45-90 lb. Pre-Breeder Seed</td>
<td>40-200 lbs. Breeder Seed</td>
<td>2,000 lb. Foundation Seed</td>
</tr>
<tr>
<td>Output</td>
<td>40-200 lb. Breeder Seed</td>
<td>2,000 lb. Foundation Seed</td>
<td>100,000 lb. Certified Seed</td>
</tr>
</tbody>
</table>
| Capital Sources | • University Funding  
• Grants  
• Special Projects  
• Arkansas Rice Research & Promotion Board | • Foundation seed sales cover variable costs  
• Labor cost covered by University  
• Arkansas Rice Research & Promotion Board supports special projects | • Certified seed sales  
• NOTE: Certified seed dealers pre-order foundation seed from RREC with 50% payment due at time of purchase | • Commercial seed sales  
• NOTE: Arkansas Rice Research and Promotion Board collects an assessment to fund research and marketing activities |

Source: (1) USDA NASS
Arkansas Foundation Seed Program

Located at the Rice Research and Extension Center in Stuttgart, Arkansas, the Foundation Seed Facility opened in 2016 to replace a facility dating back to the 1950s.

This state-of-the-art facility manages the certified foundation seed produced by the University of Arkansas System Division of Agriculture. All foundation seed is inspected throughout the entire process, from the field to the point of sale, to ensure high quality and purity.

The facility can process as much as 250 bushels of seed an hour, including pre-cleaning, cleaning, sizing and bagging and has capacity to handle more than 25 varieties of seed each year. In addition to rice seed production, the facility also produces foundation seed for soybeans and wheat. – Rice Research and Extension Center

*2017 is an estimate
Rice Foundation Seed Sales by Variety (2013-2017)

The product lifecycle of a new rice variety ranges from 3-10+ years.

Units (1 Unit = 50 lb. bag)

- Cheniere
- Francis
- LaKast
- Roy J
- Titan
- Caffey
- Diamond
- Jupiter
- Taggart
- Mermentau
- Wells

*Estimated
Financial Sustainability
Financial Sustainability by EGS Value-Chain Step

**Varietal Development & Breeder Seed Management**
- Public Sector Contributes 70% of Operating Costs; Grower-Led Commodity Association Funds the Other 30%

**Foundation Seed Production**
- Public Sector Subsidizes 40% of Operating Costs; Seed Growers Fund 60% Through Foundation Seed Purchases

**Certified Seed Production**
- Commercial Seed Companies Fund Certified Seed Production Through Seed Sales
Operational Costs For Foundation Seed Production and Processing (Rice, Soybean, and Wheat)\(^1\)

**RICE IS ONE OF THREE CROPS THAT THE UNIVERSITY OF ARKANSAS PRODUCES FOUNDATION SEED FOR**

**OVERHEAD COSTS ARE ALLOCATED ACROSS THE THREE CROPS, REDUCING THE FIXED COST BURDEN ON ANY INDIVIDUAL CROP**

**LABOR COSTS REPRESENT NEARLY HALF OF FOUNDATION SEED PRODUCTION & PROCESSING EXPENSES**

---

PUBLIC SECTOR PRODUCES 50lb BAGS OF FOUNDATION RICE SEED FOR $57*, AND SELLS NEW VARIETIES FOR $45

Sample Production Costs for Foundation Rice Seed Production

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Production</td>
<td>19%</td>
</tr>
<tr>
<td>Post Harvest Cost</td>
<td>33%</td>
</tr>
<tr>
<td>Additional Costs (Depreciation, Salary Increase, Indirect Costs)</td>
<td>48%</td>
</tr>
</tbody>
</table>

The transfer price of breeder seed in this analysis does not cover the cost of varietal development. Prices are indexed to 2016 prices.

---

*Only direct costs considered in total seed cost estimation
Arkansas Foundation Seed Program Revenue
By Crop (2000-2017)¹

RICE CONTRIBUTES THE LARGEST SHARE OF RREC FOUNDATION SEED REVENUE
INTRODUCTION OF HYBRID RICE IN 2005 LED TO A DECLINE IN RICE FOUNDATION SEED REVENUE
CONTINUED INTRODUCTION OF NEW & IMPROVED CONVENTIONAL RICE VARIETIES ENABLES COMPETITION AGAINST HYBRID OFFERINGS

Foundation Seed Field Production Costs

**Financial Sustainability**

- Rogueing represents over 25% of field production costs
- Five cost categories contribute 69% of field production costs

**Other (Rogueing)**
- 26%

**Fertilizer**
- 18%

**Herbicide**
- 10%

**Custom Application**
- 8%

**Irrigation Costs**
- 8%

**Fungicide**
- 6%

**Fixed Expenses (Machinery & Equipment, Irrigation Equip, Farm Overhead)**
- 5%

**Chicken Litter**
- 5%

**Diesel Costs**
- 4%

**Seed**
- 4%

**Repairs and Maintenance Costs**
- 6%

**Insecticide**
- 1%

**The Arkansas Foundation Seed Program does not pay a transfer fee for breeder seed, which reduces its cost of goods sold and underrepresents the value of this necessary input.**

---

Enabling Environment
University Extension Provides Clear Agronomic & Economic Guidance to Arkansas Rice Farmers

U of A Research & Extension supports rice growers on key production decisions, including: cultivar selection, planting timing, seeding rates, row spacing, irrigation, pesticide application, irrigation, drain timing, and harvest.

Authors:
Jarrod Hardke, Agronomy
Ron Baker, Verification
Tom Barber, Weed Science
Nick Bateman, Entomology
Mike Hamilton, Irrigation
Chris Henry, Irrigation
Gus Lorenz, Entomology
Ralph Mazzanti, Verification
Richard Norman, Soil Fertility
Jason Norsworthy, Weed Science
Trent Roberts, Soil Fertility
Bob Scott, Weed Science
Nathan Slaton, Soil Fertility
Yeshi Wamishe, Plant Pathology
# Financial Enabling Environment

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>DETAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Commodity Price Hedge</td>
<td><strong>Price Loss Coverage (PLC):</strong> Producers who hold base acres of wheat, feed grains, rice, oilseeds, peanuts, and pulses (covered commodities) are eligible to enroll in the PLC program on a commodity-by-commodity basis. Payments are made when market prices fall below the reference price set in the 2014 Farm Act.</td>
</tr>
<tr>
<td>Regional Commodity Price Hedge</td>
<td><strong>Agriculture Risk Coverage (ARC):</strong> Producers who hold base acres of rice, wheat, feed grains, oilseeds, peanuts, and pulses (covered commodities), are eligible to enroll in ARC on a county or individual farm basis. County ARC payments are made when county crop revenue for the enrolled commodity drops below 86 percent of the county benchmark revenue. Individual ARC payments are made when the actual individual crop revenues—summed across all covered commodities on the ARC farm—are less than 86 percent of the ARC individual benchmark revenue.</td>
</tr>
<tr>
<td>Commodity Marketing Credit</td>
<td><strong>Marketing Assistance Loan Program:</strong> A post-harvest nonrecourse commodity loan program with marketing loan provisions for producers of wheat, corn, grain sorghum, barley, oats, upland cotton, extra-long staple (ELS) cotton, long- and medium-grain rice, soybeans, other oilseeds, peanuts, wool, mohair, honey, dry peas, lentils, and small and large chickpeas. When the adjusted world price for rice (as calculated weekly by USDA), falls below loan rates, marketing loan provisions allow for repayment of loans at the lower price and for loan deficiency payments to producers who choose not to place commodities under loan.</td>
</tr>
<tr>
<td>National Crop Insurance</td>
<td><strong>Traditional crop insurance:</strong> Producers can purchase insurance policies at a subsidized rate under Federal crop insurance programs. These insurance policies make indemnity payments to producers based on current losses related to either below-average yields (crop yield insurance), or below-average revenue (revenue insurance). Both yield and revenue insurance options are available.</td>
</tr>
</tbody>
</table>

*Source: USDA ERS*
Thank you for your time and support in the development of this Arkansas Rice EGS profile.

## Stakeholders Consulted

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Glenn Bathke</td>
<td>Project/Program Director</td>
<td>Rice Research &amp; Extension Center</td>
</tr>
<tr>
<td>John Carlin</td>
<td>Assistant Director</td>
<td>Arkansas Crop Variety Improvement Program</td>
</tr>
<tr>
<td>Jay Coker</td>
<td>Board Member, Rice Farmer</td>
<td>AR Rice Research and Promotion Board</td>
</tr>
<tr>
<td>Heath North</td>
<td>Director of Seed Operations</td>
<td>Stratton Seed Company</td>
</tr>
<tr>
<td>Michael Smith</td>
<td>VP Quality and Innovation</td>
<td>Riceland Foods</td>
</tr>
<tr>
<td>Dean Oliver</td>
<td>Director-Innovation and Technical Services</td>
<td>Riceland Foods</td>
</tr>
<tr>
<td>Dr. Karen Moldenhauer</td>
<td>Professor and Rice Breeder</td>
<td>University of Arkansas</td>
</tr>
<tr>
<td>Dr. Ehsan Shakiba</td>
<td>Asst. Professor and Rice Breeder</td>
<td>University of Arkansas</td>
</tr>
<tr>
<td>Dr. Xueyan Sha</td>
<td>Assoc. Professor and Rice Breeder</td>
<td>University of Arkansas</td>
</tr>
</tbody>
</table>
Abstract: Public plant breeders at land grant universities and USDA play a critical role in the development of improved cultivars for farmers in the United States. Over the past 20 yr, a series of reports have documented the decrease in public plant breeding programs, breeder positions, and government financial support. Publicly funded programs allow breeders to focus on crop types, geographic locations, and management systems that are not sufficiently profitable to warrant significant investment from private industry. A survey was conducted in 2015 to understand the current state of cultivar development in the U.S. public sector. The survey respondents were public plant breeders actively releasing finished cultivars and inbred lines, and questions included: (i) demographic and background information; (ii) germplasm usage and exchange; (iii) intellectual property rights; (iv) breeding program funding; (v) institutional support and program size. Results indicate that public cultivar development is in a state of decline, with insufficient numbers of younger breeders working in the public sector today to maintain the current level of cultivar development as the most senior breeders retire. Funding public breeding programs continues to be a challenge, as is access to improved germplasm due to overly restrictive licensing agreements. Potential opportunities include redistribution of royalty funds to bolster revenue streams, and simplifying the germplasm exchange process to increase the likelihood of successful cultivar releases.

Conclusion: Public plant breeders play a critical role in determining the future of agriculture. Their work is varied, and includes long-term research in areas such as assessing and broadening genetic diversity, introgression of traits from wild species, development of new breeding methodologies, and expanding applications for genomic tools. Public plant breeders are responsible for the education of the next generation of plant breeders (both public and private), and require active breeding programs to provide hands-on learning for students, from initial crosses through the release process. In this study, we have focused on their role in cultivar development. Plant breeders in the public sector often focus on minor crops, cover crops, perennial crops, and geographies and farming systems that are under-served by the private sector. By improving these crops, regions and systems with well-adapted varieties, public plant breeders create a more resilient agricultural landscape that buffers against the increasing climactic and economic fluctuations of the 21st century. Yet plant breeding in the public sector is in a current state of crisis due to lack of sufficient funding to support this public good. In addition, the increasing use of restrictive IP limits public plant breeders’ access to useful germplasm necessary for the development of improved cultivars. Public plant breeders have an opportunity to address this challenge by working with their universities and technology licensing offices, and one another to reduce the restrictive nature of their licensing agreements, especially for germplasm exchange with other public programs, and by redistributing royalty money allocations to increase support directly for cultivar development.

Public Plant Breeder Respondent Distribution by...

**Institution**
- USDA–Agricultural Research Service, 31, 16%
- Land-Grant University/State Agricultural Experiment Station, 159, 84%

**Crop Type**
- Field crops 53%
- Vegetables and pulses 26%
- Fruits, nuts, trees, and ornamentals 21%

**Tenure**
- Yes 72%
- No 28%

**Crop Biology**
- Both hybrid and pure line, 14, 7%
- Pure line, 82, 43%
- Hybrid, 40, 21%
- Clonal, 55, 29%

Breeders Report Employing an Average of 8.4 Persons

**Average # of Positions**

- Undergraduate students: 2.9
- Graduate students: 2.2
- Field technicians: 1.7
- Lab technicians: 0.7
- Post-doctoral students: 0.5
- Other: 0.4

All figures as percentages

Breeding Programs Encourage and Incentivize Cultivar Development, But Only 43% of Breeders Report That Their Position Would Be Replaced if they Left

“If you work for an institution that offers tenure, does cultivar development count towards the tenure process?”

- Yes: 85%
- No: 15%

“If you were to leave your job for any reason, will your position be replaced?”

- Yes: 43%
- No: 24%
- Unsure: 33%

“How much does your institution encourage your cultivar development work?”

- Strongly encourages: 44.8%
- Somewhat encourages: 35.9%
- Neither encourages nor discourages: 16.0%
- Somewhat discourages: 2.8%
- Strongly discourages: 0.6%

All figures as percentages

Breeders Most Commonly Source Germplasm From Other Public Breeding Programs

“Which of the following germplasm sources do you use the most?”

- Other Public Breeding Programs: 49.4%
- USDA GRIN: 24.7%
- Wild Collections: 9.0%
- Other: 6.2%
- Private Industry: 5.6%
- Internal Program Inventory: 2.8%
- CGIAR: 2.3%
Positive Correlation Between Years Worked as a Public Plant Breeder and the Number of Cultivars Released

How many years have you worked as a plant breeder?

Number of cultivars released by number of years worked as a public plant breeder

Breeders’ Employers Contribute Less Than 25% of Annual Operating Costs

<table>
<thead>
<tr>
<th>Funding Source</th>
<th>% of Breeding Program Funding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employer</td>
<td>24.1</td>
</tr>
<tr>
<td>Commodity check-off programs</td>
<td>17.8</td>
</tr>
<tr>
<td>USDA competitive grants</td>
<td>14.2</td>
</tr>
<tr>
<td>Royalty money</td>
<td>12.3</td>
</tr>
<tr>
<td>Private industry</td>
<td>12.3</td>
</tr>
<tr>
<td>Federal formula funds</td>
<td>11.6</td>
</tr>
<tr>
<td>Other</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Mean percentage distribution of funding sources for breeding programs based on public plant breeder respondents releasing finished cultivars (including inbred lines) and surveyed in 2015 (N = 177).

Distribution of Breeding Programs’ by Annual Operating Costs

65.9% of Respondents Report Operating Costs Below $300,000

Regardless of Crop Type, Breeding Programs’ Average Annual Operating Costs is Reported to be Below $300K

Majority of Respondents Indicate That Their Breeding Program is Under-Funded

### Breeding Programs by Annual Operating Costs

<table>
<thead>
<tr>
<th>Do you feel your program is:</th>
<th>N</th>
<th>Less than $100,00</th>
<th>$100,000– $199,999</th>
<th>$200,000– $299,999</th>
<th>$300,000– $399,999</th>
<th>$400,000– $499,999</th>
<th>$500,00 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very or somewhat under-funded</td>
<td>100</td>
<td>34.0</td>
<td>30.0</td>
<td>17.0</td>
<td>10.0</td>
<td>4.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Neither under nor well funded</td>
<td>37</td>
<td>13.5</td>
<td>27.0</td>
<td>18.9</td>
<td>8.1</td>
<td>16.2</td>
<td>16.2</td>
</tr>
<tr>
<td>Very or somewhat well funded</td>
<td>48</td>
<td>6.3</td>
<td>10.4</td>
<td>22.9</td>
<td>12.5</td>
<td>20.8</td>
<td>27.1</td>
</tr>
</tbody>
</table>

### Does your program generate royalties?

<table>
<thead>
<tr>
<th>Does your program generate royalties?</th>
<th>N</th>
<th>15.8</th>
<th>22.6</th>
<th>22.6</th>
<th>9.8</th>
<th>13.5</th>
<th>15.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>133</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>48</td>
<td>43.8</td>
<td>31.3</td>
<td>4.2</td>
<td>12.5</td>
<td>4.2</td>
<td>4.2</td>
</tr>
</tbody>
</table>

### Satisfaction with royalty distribution:

<table>
<thead>
<tr>
<th>Satisfaction with royalty distribution:</th>
<th>N</th>
<th>14.0</th>
<th>18.6</th>
<th>16.3</th>
<th>18.6</th>
<th>18.6</th>
<th>14.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very or somewhat dissatisfied</td>
<td>43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neither dissatisfied nor satisfied</td>
<td>23</td>
<td>8.7</td>
<td>30.4</td>
<td>21.7</td>
<td>0.0</td>
<td>13.0</td>
<td>26.1</td>
</tr>
<tr>
<td>Very or somewhat satisfied</td>
<td>62</td>
<td>19.4</td>
<td>22.6</td>
<td>25.8</td>
<td>6.5</td>
<td>11.3</td>
<td>14.5</td>
</tr>
</tbody>
</table>

All figures as percentages

### Respondent Responses Stratified by Their Breeding Programs’ Reported Annual Operating Costs

**Crop type**  
<table>
<thead>
<tr>
<th>Crop type</th>
<th>All</th>
<th>$&lt;100,000</th>
<th>$100,000–$199,999</th>
<th>$200,000–$299,999</th>
<th>$300,000–$399,999</th>
<th>$400,000–$499,999</th>
<th>$500,000 or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>187</td>
<td>22.5</td>
<td>24.1</td>
<td>19.3</td>
<td>10.2</td>
<td>10.7</td>
<td>13.4</td>
</tr>
<tr>
<td>Field crops</td>
<td>100</td>
<td>20.0</td>
<td>22.0</td>
<td>23.0</td>
<td>12.0</td>
<td>12.0</td>
<td>11.0</td>
</tr>
<tr>
<td>Fruits, trees, nuts, and ornamentals</td>
<td>39</td>
<td>30.8</td>
<td>30.8</td>
<td>15.4</td>
<td>2.6</td>
<td>0.0</td>
<td>20.5</td>
</tr>
<tr>
<td>Vegetables and pulses</td>
<td>48</td>
<td>20.8</td>
<td>22.9</td>
<td>14.6</td>
<td>12.5</td>
<td>16.7</td>
<td>12.5</td>
</tr>
</tbody>
</table>

**Years worked as a public plant breeder**  
<table>
<thead>
<tr>
<th>Years worked as a public plant breeder</th>
<th>0–5 yr</th>
<th>6–10 yr</th>
<th>11–15 yr</th>
<th>16–20 yr</th>
<th>21 yr or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>11</td>
<td>27.3</td>
<td>27.3</td>
<td>9.1</td>
<td>9.1</td>
</tr>
<tr>
<td>Field crops</td>
<td>28</td>
<td>25.0</td>
<td>14.3</td>
<td>39.3</td>
<td>10.7</td>
</tr>
<tr>
<td>Fruits, trees, nuts, and ornamentals</td>
<td>20</td>
<td>20.0</td>
<td>30.0</td>
<td>25.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Vegetables and pulses</td>
<td>24</td>
<td>20.8</td>
<td>41.7</td>
<td>12.5</td>
<td>8.3</td>
</tr>
</tbody>
</table>

**Do you feel your program is:**  
<table>
<thead>
<tr>
<th>Do you feel your program is:</th>
<th>Very or somewhat under-funded</th>
<th>Neither under nor well funded</th>
<th>Very or somewhat well funded</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>100</td>
<td>37</td>
<td>48</td>
</tr>
<tr>
<td>Field crops</td>
<td>25.0</td>
<td>13.5</td>
<td>6.3</td>
</tr>
<tr>
<td>Fruits, trees, nuts, and ornamentals</td>
<td>30.8</td>
<td>27.0</td>
<td>10.4</td>
</tr>
<tr>
<td>Vegetables and pulses</td>
<td>20.0</td>
<td>18.9</td>
<td>22.9</td>
</tr>
</tbody>
</table>

**Does your program generate royalties?**  
<table>
<thead>
<tr>
<th>Does your program generate royalties?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>133</td>
<td>48</td>
</tr>
<tr>
<td>Field crops</td>
<td>15.8</td>
<td>43.8</td>
</tr>
<tr>
<td>Fruits, trees, nuts, and ornamentals</td>
<td>22.6</td>
<td>31.3</td>
</tr>
<tr>
<td>Vegetables and pulses</td>
<td>22.6</td>
<td>4.2</td>
</tr>
</tbody>
</table>

**Satisfaction with royalty distribution:**  
<table>
<thead>
<tr>
<th>Satisfaction with royalty distribution:</th>
<th>Very or somewhat dissatisfied</th>
<th>Neither dissatisfied nor satisfied</th>
<th>Very or somewhat satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>14.0</td>
<td>8.7</td>
<td>19.4</td>
</tr>
<tr>
<td>Field crops</td>
<td>18.6</td>
<td>30.4</td>
<td>22.6</td>
</tr>
<tr>
<td>Fruits, trees, nuts, and ornamentals</td>
<td>16.3</td>
<td>21.7</td>
<td>25.8</td>
</tr>
<tr>
<td>Vegetables and pulses</td>
<td>18.6</td>
<td>0.0</td>
<td>6.5</td>
</tr>
</tbody>
</table>

**Will your position be replaced?**  
<table>
<thead>
<tr>
<th>Will your position be replaced?</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>77</td>
<td>43</td>
<td>59</td>
</tr>
<tr>
<td>Field crops</td>
<td>9.1</td>
<td>13.0</td>
<td>27.1</td>
</tr>
<tr>
<td>Fruits, trees, nuts, and ornamentals</td>
<td>23.4</td>
<td>14.3</td>
<td>39.0</td>
</tr>
<tr>
<td>Vegetables and pulses</td>
<td>14.3</td>
<td>11.6</td>
<td>18.6</td>
</tr>
</tbody>
</table>

Respondents Believe Grants Have a Larger Influence on the Focus of Breeding Work Than Private Industry

Table 8. Impact of funding sources on focus of breeding work reported by public plant breeder respondents releasing finished cultivars (including inbred lines), and surveyed in 2015.

<table>
<thead>
<tr>
<th>Source</th>
<th>Private Industry</th>
<th>Grants</th>
<th>Royalties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>29.0</td>
<td>12.3</td>
<td>52.9</td>
</tr>
<tr>
<td>A little</td>
<td>22.0</td>
<td>20.3</td>
<td>19.8</td>
</tr>
<tr>
<td>Some</td>
<td>24.2</td>
<td>27.8</td>
<td>10.2</td>
</tr>
<tr>
<td>Quite a bit</td>
<td>14.5</td>
<td>30.0</td>
<td>12.3</td>
</tr>
<tr>
<td>A great deal</td>
<td>10.2</td>
<td>9.6</td>
<td>4.8</td>
</tr>
</tbody>
</table>

All figures as percentages

## Intellectual Property Rights Are Routinely Secured on Public Breeders’ Cultivars

Likelihood of usage of various forms of intellectual property rights to protect cultivars (including inbred lines) released by public plant breeder respondents and surveyed in 2015.

<table>
<thead>
<tr>
<th>Form of intellectual property rights</th>
<th>Field crops</th>
<th>Fruits, nuts, trees, ornamentals</th>
<th>Vegetables and pulses</th>
</tr>
</thead>
<tbody>
<tr>
<td>License</td>
<td>78.2</td>
<td>77.1</td>
<td>79.4</td>
</tr>
<tr>
<td>Plant variety protection certificate</td>
<td>85.4</td>
<td>34.4</td>
<td>85.3</td>
</tr>
<tr>
<td>Plant patent</td>
<td>12.5</td>
<td>86.5</td>
<td>9.7</td>
</tr>
<tr>
<td>Trademark</td>
<td>11.1</td>
<td>65.7</td>
<td>25.8</td>
</tr>
<tr>
<td>Utility patent</td>
<td>20.9</td>
<td>3.3</td>
<td>6.7</td>
</tr>
</tbody>
</table>

**All figures as percentages**

Breeders Commonly Share Germplasm (95%), but the Associated Material Transfer Agreements Restrict Breeders’ Freedom to Operate

How do often does germplasm leave your institution with a material transfer agreement (MTA)?

- Never: 6%
- Rarely: 7%
- Sometimes: 26%
- Mostly: 35%
- Always: 26%

How does the language of the MTA that you receive impact your freedom to operate as a plant breeder?

- Somewhat restricts: 53%
- Strongly restricts: 15%
- Neither restricts nor improves: 28%
- Somewhat improves: 2%
- Strongly improves: 2%