

Early Generation Seed System Case Study

North Carolina Sweetpotato

February 2018



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North Carolina Sweetpotato Case Study

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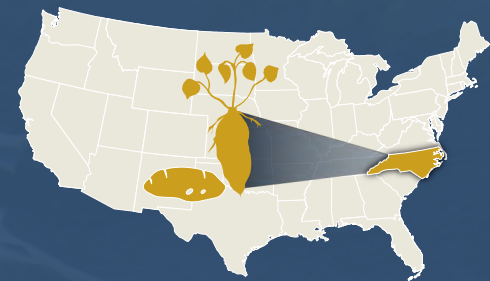
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Executive Summary



Acronyms

MPRU | Micropropagation Repository Unit

NC | The State of North Carolina

NCCIA | North Carolina Crop Improvement Association

NC State | North Carolina State University

Operational Overview by Seed System Function

VARIETAL DEVELOPMENT & SEED DEPLOYMENT



Varietal Development

NC States' Sweetpotato Breeding and Genetics Program manages all varietal development activities. Breeders work with thousands of different lines each season, and engage with growers to evaluate and bulk up promising pre-release varieties.



Seed Multiplication

NC State's Micropropagation Repository Unit (MPRU) is charged with virus indexing, breeder seed maintenance, tissue culture multiplication, greenhouse foundation seed production, and distribution of foundation seed to certified seed growers.



Certified Seed Production

Certified seed growers purchase Nuclear Plants (G0) from the MPRU for multiplication into G0, G1, and G2 cuttings and roots for sale to commercial growers, and incorporation into their own integrated commercial farming operations. The North Carolina Crop Improvement Association (NCCIA) manages the sweetpotato certification process.

FARMER PRODUCTION, MARKETING, AND KEY DEMAND SEGMENTS



Farm Production

Commercial growers, who are often times also certified seed growers, plant G2 roots for the production of sweetpotatoes that are harvested, cleaned, and sorted on-farm. Commercial growers are large, planting between 500 to 30,000 acres. They enter into direct sales contracts with wholesalers and grocers. Premium roots, known as '#1s', are sold whole. Non-premium roots are sold into the processors' value-chain.



Industry Advocacy

The North Carolina SweetPotato Commission Inc. is a nonprofit corporation made up of over 400 Sweetpotato growers along with the packers, processors and business associates that support them. The sole purpose of the commission is to increase sweetpotato consumption through education, promotional activities, research and honorable horticultural practices among its growers. The NC Foundation Seed Producers is the nonprofit entity charged with foundation seed production across all commodities in the state.



Demand Segments

An estimated 70% of sweetpotatoes grown in North Carolina are sold directly to chain stores, terminal market facilities, or foodservice providers. The remaining 30% is sold to processors for canning, flaking, chipping, frying, freezing or baby food. Ratio is likely to shift toward processing into the future.

ENABLING ENVIRONMENT STAKEHOLDERS

[NCSU College of Agriculture and Life Sciences](#)

[NCSU Department of Horticultural Science](#)

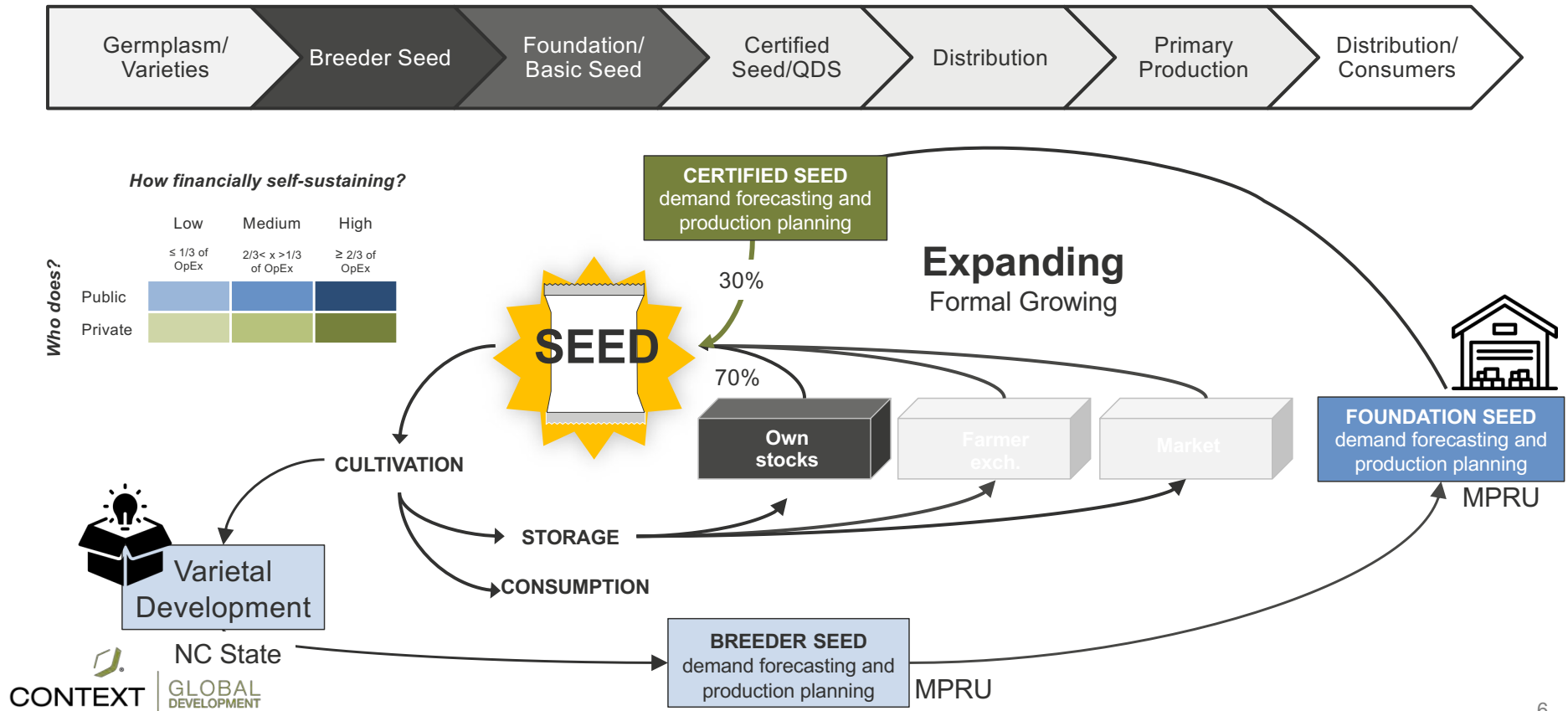
[National Clean Plant Network](#)

[NCFSPA](#)

[USDA](#)

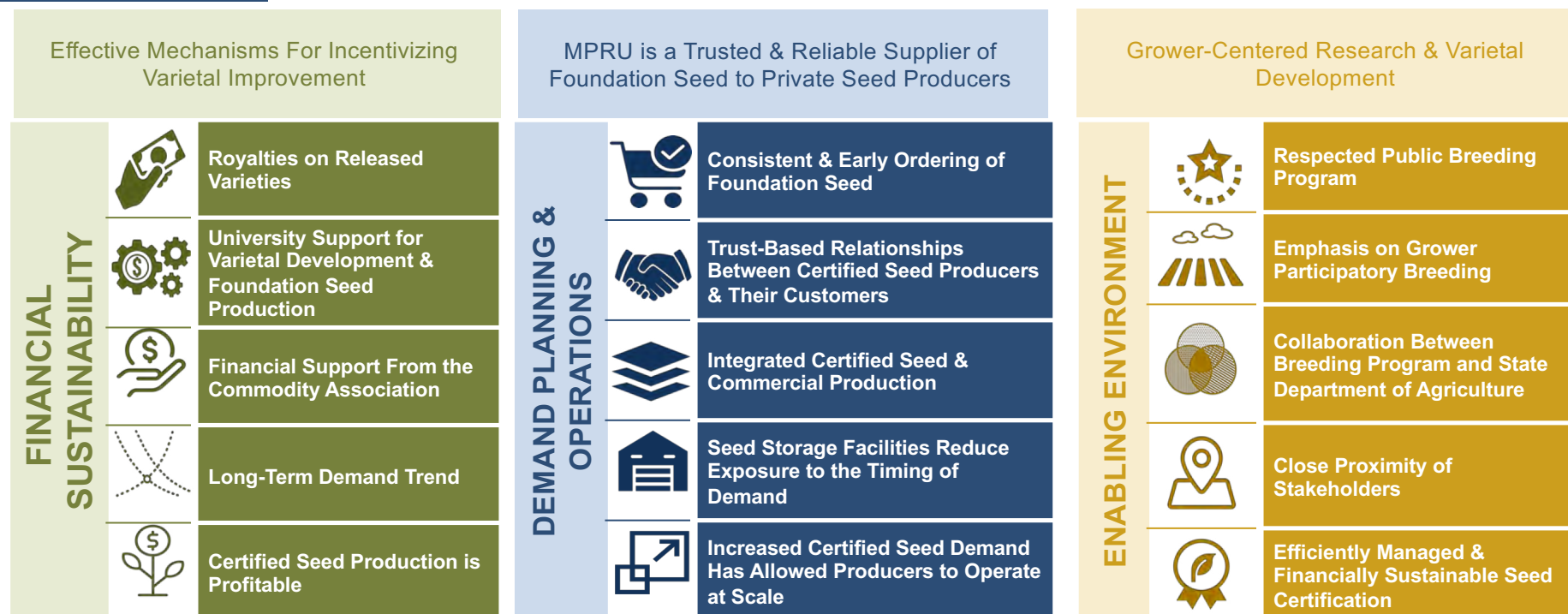
SEED SYSTEM STRUCTURE

Public Sector Funds Varietal Development and Subsidizes Foundation Seed Production



KEY SUCCESS FACTORS

Summary of Key Success Factors



Financial Conclusions on Following Slides

Financial Sustainability



Royalties on Released Varieties

Royalties support breeding program activities, but contribute less than 20% of the Sweetpotato Breeding & Genetics Program at North Carolina State University's annual budget. They are assessed as a percentage of certified seed sales, and collected and remitted to NC State by certified seed growers. In 2017, the royalties on certified seed was 5% on in-state sales, and 10% on out-of-state sales. Collected royalties are distributed to several entities, including: the Henry M. Covington Endowment for sweetpotato research and extension, the Office of Technology Commercialization and New Ventures, North Carolina State College of Agriculture and Life Sciences, NC State Department of Horticultural Sciences, and the Inventor(s) of the variety.



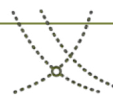
University Support for Varietal Development & Foundation Seed Production

NC State, which is state funded, subsidizes the cost of sweetpotato varietal development and foundation seed production. The breeding and foundation seed functions at NC State rely on the support it receives from the university in the form of human (e.g., researchers and support staff), and physical capital (e.g., offices, labs, greenhouse space, equipment, transportation, informational technology).



Financial Support From the Commodity Association

The NC SweetPotato Commission represents the interests of over 400 sweetpotato growers in the state and provides annual and project-specific funding to the Sweetpotato Breeding and Genetics Program and to the Micropropagation Repository Unit at NC State University. Researchers at NC State and the NC SweetPotato Commission enjoy a close working relationship, that is based on mutual reliance.



Long-Term Demand Trend

Optimism over the long-term demand forecast for sweetpotatoes, due to the substitution of sweetpotatoes for potatoes, has increased private sector sponsorship of varietal development.



Certified Seed Production is Profitable

A small number (~11) of highly skilled certified seed producers are expert multipliers of foundation seed ('nuclear plants'), and accomplished business persons who profit from the sale of clean, true-to-type, certified seed.

Demand Planning and Operations



Consistent & Early Ordering of Foundation Seed

Early ordering of foundation seed from a small group of trusted certified seed producers limits NC State's exposure to over production. Certified seed producers have a close relationship with the Micropropagation Repository Unit (MPRU), and place their foundation seed ('nuclear plants') orders months in advance. The combination of reliable customers and early ordering enables NC State to make accurate demand forecasts.



Trust-Based System Between Certified Seed Producers & Their Customers

Certified seed growers rely on trust-based relationships with their long-time customers to develop demand forecasts. They must be confident in the prospective demand for their seed, because they bear the financial risk of overproduction and make strategic production decisions with working capital implications years in advance of certified seed sales.



Integrated Certified Seed & Commercial Production

Over production risk is mitigated because certified seed growers are also commercial sweetpotato producers, which enables them to plant unsold certified seed in their own commercial sweetpotato fields.



Seed Storage Facilities Reduce Exposure to the Timing of Demand

Certified seed producers have their own on-site storage facilities that are cool, dry, and ventilated, which extends the length of time that roots can be sold thereby reducing spoilage costs due to microbial contamination.



Increased Certified Seed Demand Has Allowed Producers to Operate at Scale

Seed producers have increased their scale of production in response to the crop's growing demand. As a result, certified seed producers have benefited from economies of scale via lower per-unit fixed costs on income statement items like depreciation, salaries, and equipment servicing/repairs. In turn, seed producers have an higher incentive to overproduce than under-produce, because the foregone profit, or opportunity cost, of under-producing certified seed is higher.

KEY SUCCESS FACTORS

Enabling Environment



Respected Public Breeding Program

NC State's Sweetpotato Breeding and Genetics Program positively, and meaningfully impacted the economics of sweetpotato production in NC with the release of the 'Covington' variety. The Program has the respect of certified seed growers, commercial producers, and industry, who all rely on it to develop new varieties that are high yielding, feature exceptional appearance and/or processing qualities, and are disease and insect resistant.



Emphasis on Grower Participatory Breeding

A key feature of NC State's Sweetpotato Breeding and Genetics Program is its engagement with 6-8 select growers to evaluate promising varieties in on-farm trials across multiple environments, before they are released. Farmer participatory breeding strengthens the relationship between breeders and growers, stretches public sector resources, hastens varietal speed to market, enables bulking prior to release, and stimulates adoption of new varieties.



Collaboration Between Breeding Program and State Department of Agriculture

The breeding program works closely with the North Carolina Department of Agriculture & Consumer Services, which provides human and physical resources that the program relies on for field trials, mechanized planting/cultivation/harvesting, seed storage, and general management. This relationship allows the breeding program to stretch its resources, and evaluate more lines than it could on its own.



Close Proximity of Stakeholders

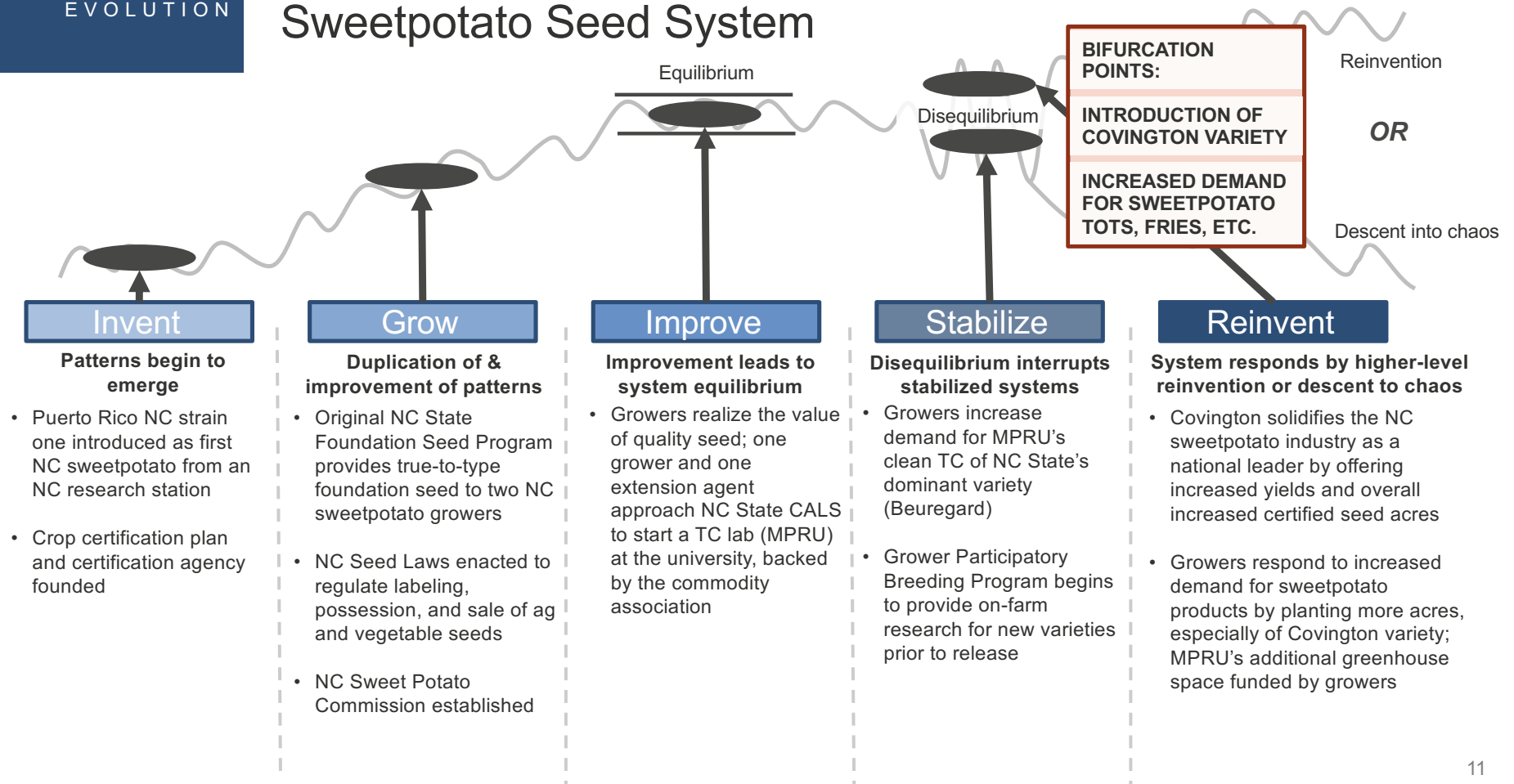
Key seed system stakeholders are located within a two-hour drive of one another, which increases connectivity and reduces transportation costs of sweetpotato seed, which is bulky and relatively expensive to transport. Varietal development and foundation seed operations are co-located on the NC State campus. The state's seed certification agency is located a few miles away. And the surrounding countries are the primary sweetpotato production counties in the state and the U.S.



Efficiently Managed & Financially Sustainable Seed Certification

Industry respected and efficiently managed seed certification function through the North Carolina Crop Improvement Association.

Key Events That Shaped the Evolution of the NC Sweetpotato Seed System



SEED SYSTEM EVOLUTION

North Carolina Sweetpotato Growers' Recognition of the Value Proposition of Improved Seed Spurred the Development Formal Seed System Development

Researchers at NC State Univ. endeavored to develop a variety that could compete with the 'Beauregard' variety, which quickly became the industry standard after its release in 1987 by LSU AgCenter

'Covington'¹

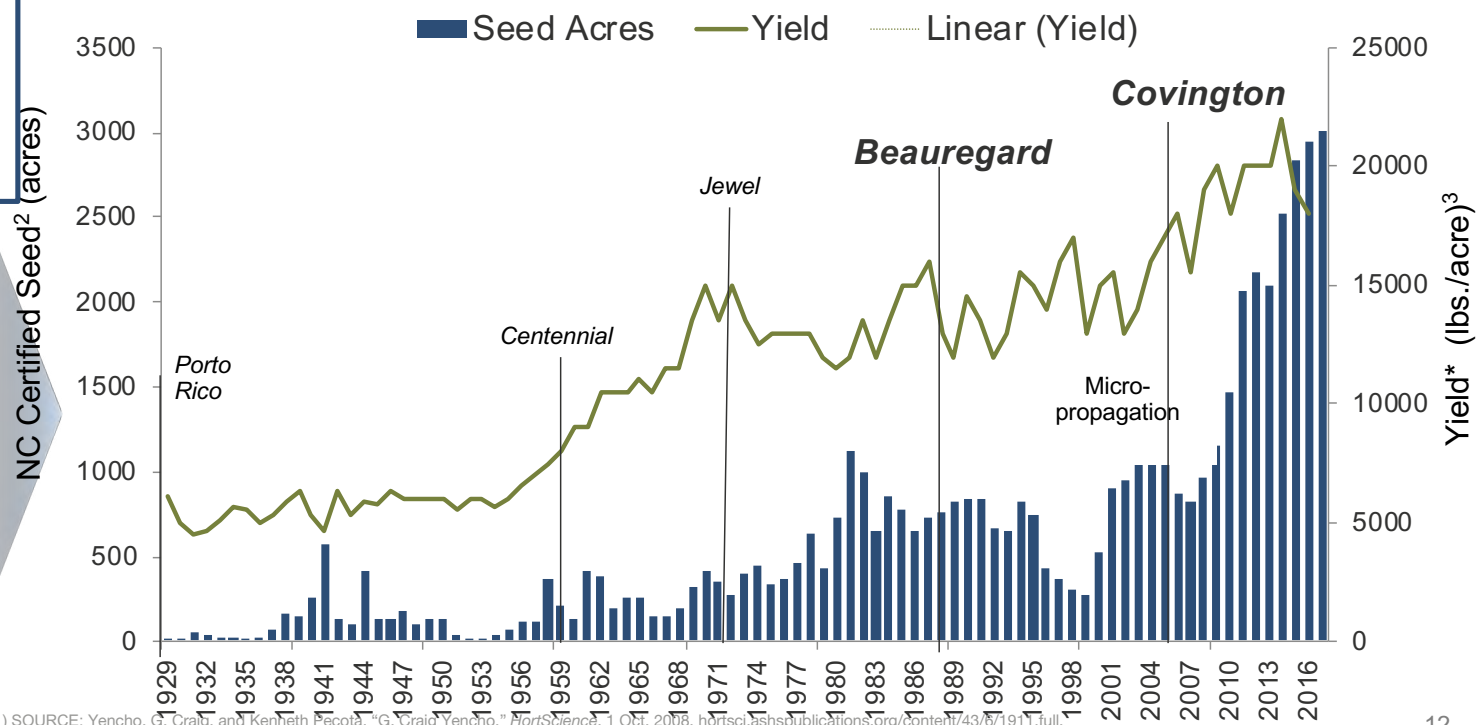


'Beauregard'



CONTEXT GLOBAL DEVELOPMENT

Yield and Certified Seed Acres Over Time



(1) SOURCE: Yencho, G. Craig, and Kenneth Pecota. "G. Craig Yencho." *HortScience*, 1 Oct. 2008, hortsci.ashspublications.org/content/43/6/1911.full.
 (2) SOURCE: North Carolina Crop Improvement Association
 (3) SOURCE: USDA National Agricultural Statistics Service

North Carolina Sweetpotato EGS System

	1900-1959	1960-1999	2000-Present
FINANCIAL Levies Royalties	<p>1862- Morrill Act passed to provide land and funding for agricultural studies</p>		<p>2016- Continuing referendum passed to allow growers to assess themselves at \$15/acre; NC Sweet Potato Commission invoices growers each year based on independent assessments</p>
DEMAND PLANNING/OPERATIONS Technology Systems	<p>1950s- Original foundation seed program and provided true-to-type seed to two seed growers in NC</p> <p>1929- Puerto Rico NC strain one variety was the first variety introduced from the North Carolina sweetpotato research station</p>	<p>1990s- Bill Jester (extension agent) and Kendall Hill (grower) start meristem project to develop clean TC material; approach NCSU CALS to start a TC lab for foundation seed at NC State</p> <p>1997- MPRU at NC State est. to produce pathogen-free elite sweet potato plants from TC. Initially funded by NC Sweet Potato Commission based on Jester and Hill's push for clean TC materials</p>	<p>2001- NC State's grower participatory breeding program begins and becomes a major factor in Covington's adoption and success; financial support given by NC Sweet Potato Commission</p> <p>2005- Covington variety released by NC State and planted on 90% of NC acres and 35-40% of U.S. acres.</p> <p>Continued- Wholesalers and retailers instituted competitive bidding processes for growers to submit willingness to sell prices. Led to a decrease in planted acres in 2017.</p> <p>Continued third-party quality control by NCCIA</p>
ENABLING ENVIRONMENT Policies Stakeholders	<p>1877- NC Dept. of Agriculture est. at the request of growers for organized lawmaking and representation</p> <p>1928- Modern-day NC Crop Improvement developed as the NC Purebred Crop Seed Program at modern-day NC State</p> <p>1929- Crop certification plan developed and enacted into NC State law; NCCIA became member of the modern-day Association of Official Seed Certifying Agencies</p>	<p>1961- NC Sweet Potato Commission chartered by six growers</p> <p>1963- NC Seed Law passed to regulate the labeling, possession, and sale of agricultural and vegetable seeds intended for planting</p>	

North Carolina Sweetpotato – EGS System Key Takeaways

- The MPRU at NC State, and the industry's subsequent quality foundation seed availability, owes its roots to the collaboration between a grower (Kendall Hill) and an extension agent (Bill Jester) who were concerned about seed quality and genetic drift. These actors played a key role in the beginnings of the initial meristem research for NC sweet potatoes and were able to present their findings and vision for a quality TC source to NC State. The recognition by growers of the need for quality seed, coupled with the collaboration between growers, extension, the land grant university, and backing by the commodity association allowed MPRU to come into existence as a publicly and privately funded organization.
- The original foundation seed program began in the 1950s when sweet potato breeding was ramping up at NC State. At this time, the foundation seed program only supplied seed (vines) for two sweet potato growers in North Carolina. These two foundation seed growers would sell clean material to growers in the local farming community as well as outside of North Carolina. As demand for clean seed grew, MPRU became the answer to meet this demand (with financial backing from the NC sweet potato commission and other grants and public funding). This demand has not waned in recent years and in fact, has led to sweet potato growers assessing an additional checkoff to fund a larger greenhouse for MPRU. This commitment to the program shows that growers value the service and believe it is vital to the success of the industry. Dr. Craig Yencho mentions that if demand for certified seed doubled in North Carolina, the seed growers that work with MPRU would easily be able to supply it.
- NC State's most successful sweet potato variety, Covington, saw the success it did due to two factors: first, Covington showed better pack-out and more dependability in disease testing compared to previous popular sweet potato varieties. The second, was that Covington was the first release from NC State that was developed through the Grower Participatory Breeding Program. This program allowed for on-farm testing by select growers of the new variety. Not only were the selected test growers receiving information about this new variety from their trials, but they were also passing this information along to fellow sweet potato growers in the region. The ability for growers to see how Covington performed in real growing conditions by fellow, trusted growers led to higher adoption rates (and a pulling demand) when Covington was released.



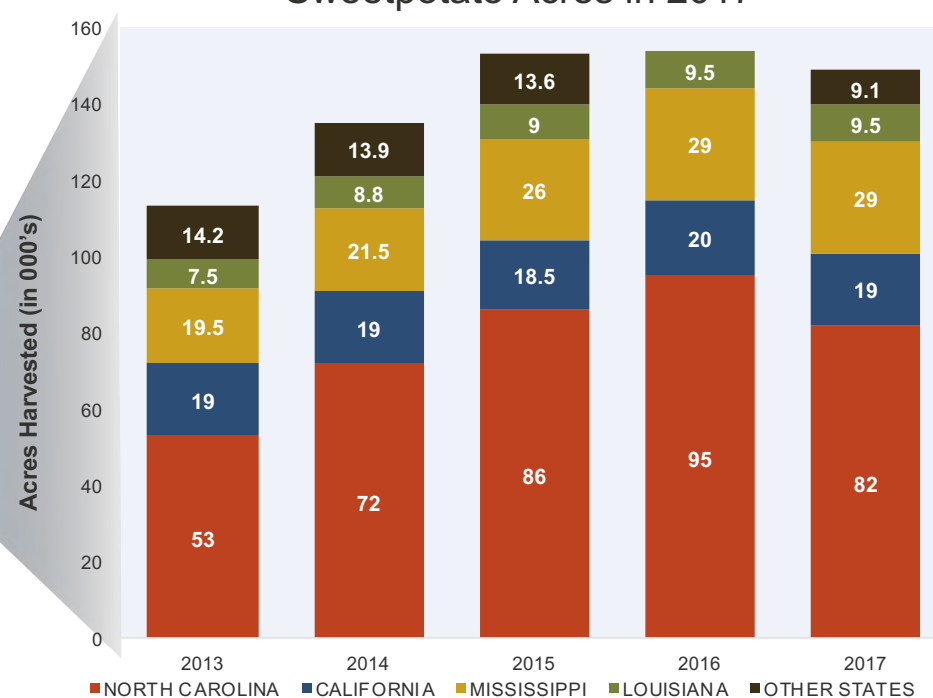
Market Dynamics

Sweetpotato is the Sixth Most Important Food Crop after Rice, Wheat, Potatoes, Maize and Cassava¹

China Produced Over 2/3 of Global Sweetpotato Production in 2014²

#Country	2014 Production Total (tons)	% of Total
1 China	71,539,950	67%
2 Nigeria	3,775,425	4%
3 Tanzania	3,500,699	3%
4 Ethiopia	2,701,599	3%
5 Mozambique	2,400,000	2%
6 Indonesia	2,382,658	2%
7 Angola	1,928,954	2%
8 Uganda	1,863,000	2%
9 Vietnam	1,401,055	1%
10 United States of America	1,341,910	1%
11 Madagascar	1,143,499	1%
12 India	1,087,880	1%
13 Rwanda	940,786	1%
14 Japan	886,500	1%
15 Kenya	763,643	1%
16 All Others	9,178,995	9%
Total	106,836,553	100%

North Carolina Harvested 55% of US Sweetpotato Acres in 2017³



(1) SOURCE: International Potato Center (<https://cipotato.org/crops/sweetpotato/sweetpotato-facts-and-figures/>)

(2) SOURCE: FAOSTAT. Accessed [8/12/2017]. <http://www.fao.org/faostat/en/#data/QC>

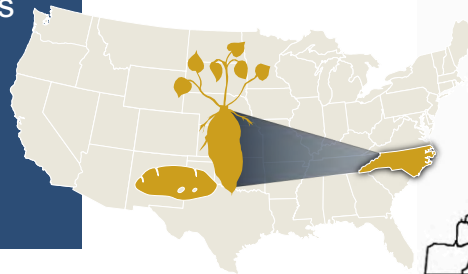
(3) SOURCE: USDA, National Agricultural Statistics Service Quickstats database and USDA, Economic Survey calculations

Recognition of Sweetpotato's Relative Health Benefits Compared to Potato Contributed to a 3lb Increase in Domestic Per Capita Consumption Between 2000 (4.2) and 2016 (7.2)

North Carolina
sweetpotato harvested acres
increased

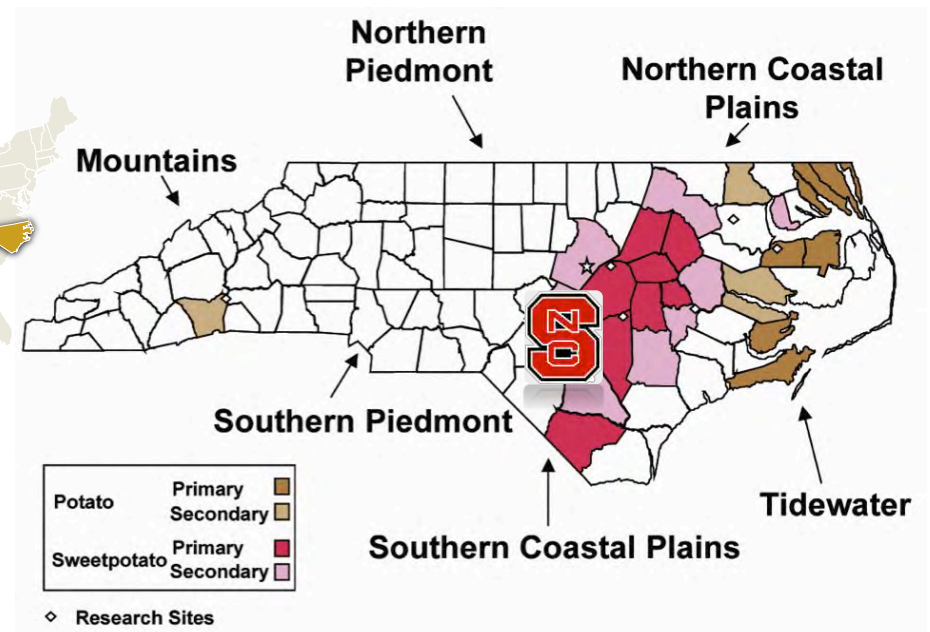
97%

between 1997 and 2017



The North Carolina State University (NC State) Breeding & Genetics Program is located in the core of the sweetpotato production region

NC State varieties of sweetpotato are planted on approximately 90% of the acres in NC, including 'Covington' which accounted for \$355 million in farm-gate revenue in 2016¹



SOURCE: Sweetpotato and Potato Breeding and Genetics Programs

Sweetpotato Demand Drivers



Healthy Eating. Positive consumption trends in US, Canada, and Europe due to millennial dietary preference for healthful foods, like sweetpotatoes which are rich in fiber and vitamins A and C. In response, the variety of sweetpotato products available for consumption in restaurants and in the home has increased.



Substitution of Sweetpotatoes for Potatoes. Processors are responding to consumer demand for processed sweetpotato products, namely fries and chips, and are sponsoring research for the development of new varieties that have preferred processing characteristics, like: starch content, dry matter, flavor (sweetness, etc.).



International Growth. As sweetpotato consumption increases in Europe, various markets, including the U.S. (North Carolina, California, Mississippi, and Louisiana), Spain, N. Africa, and E. Africa are expected to expand production to capitalize on increased demand.

Regional Market Dynamics



Formal seed system challenged by low-cost informal seed

Sweetpotato is asexually propagated, which enables seed to be produced easily and cheaply by cutting vines from existing plantings. This low cost, uncertified option for seed, competes with certified seed that is more expensive because it is priced to recoup a portion of the certification system's costs. An estimated 70% of sweetpotato acres in NC are planted with non-certified seed. Majority of seed has passed through certified stage, but generations beyond the third are widely used.



Varietal dominance

'Covington' variety was released in 2005 by NC State. It is planted on 90% of the sweetpotato acres in NC, and 35-40% of the sweetpotato acres nationwide. Rate of adoption is often used as a proxy for the success of a new sweetpotato variety. Along this metric, 'Covington's success is undeniable. A byproduct of high varietal adoption is reduced genetic diversity, which increases the risk of epidemics.



Consolidated production

Estimated that 10 growers produce 60%+ of North Carolina's sweetpotato crop. Further these growers are largely vertically integrated, producing certified seed, sweetpotatoes, and post-harvest value addition including cleaning, sorting, packing, and in some cases, processing.

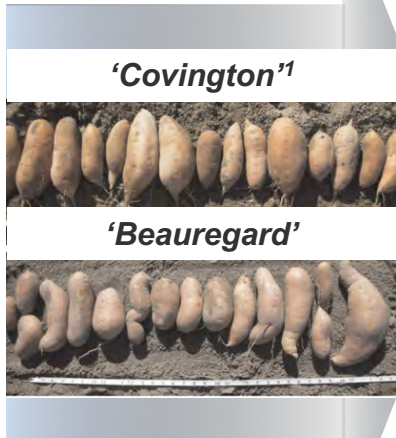
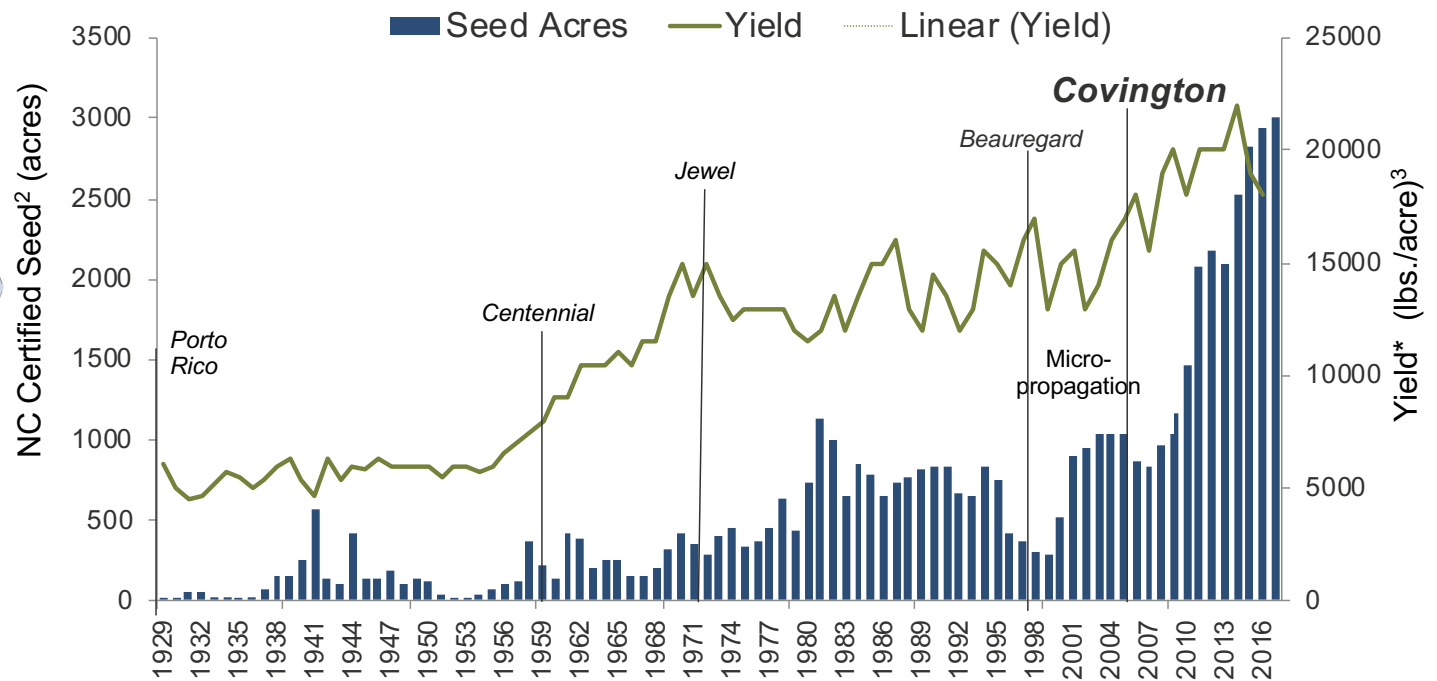


Consolidated purchasing power

Large wholesalers and retailers have recently instituted competitive bidding processes, whereby growers submit the prices at which they are willing to sell their sweetpotato production. This process, in combination with the entry of large processors to the market has lowered margins for growers, and was a contributing factor to a 15% reduction in the number of planted acres in 2017. Another contributing factor is that prevailing prices from processors is estimated to be half that of the table stock (fresh sweetpotato) market, because processors do not have the same aesthetic requirements.

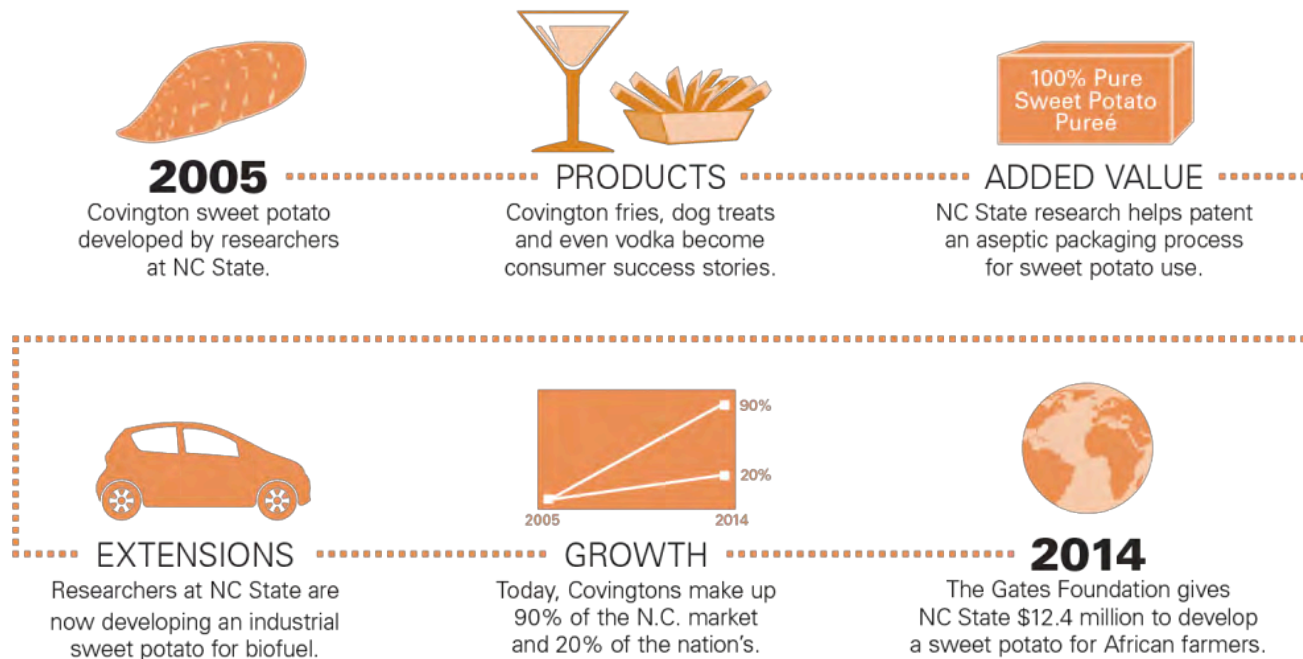
Grower Recognition of the Value of Disease Free and Uniform Production Spurred the Development of the Formal Seed System

Yield and Certified Seed Acres Over Time



'Covington' Variety Brought NC State's Sweetpotato Breeding Program to Prominence

How plant science works: a sweet (potato) story of success in under 10 years.



Market Impact of ‘Covington’ Sweetpotato Variety

**“NC State
Sweetpotato
Breeding:**
Globally Engaged,
Locally Relevant”

Varietal Adoption



North Carolina

~90% of all sweetpotatoes
grown in NC are ‘Covington’

~3,500 acres in 2005 to
~85,000 acres in 2016
(>\$355 M annual farm-gate value)

United States

~40% of of the
U.S. sweetpotato
crop is of the
‘Covington’ variety
(NC production is
the driver)

Value Creation



US farm-gate value > \$550M/yr.

Dominant US export variety, ~25% of crop








2005 to 2015 > \$2.5 Billion in farm revenue



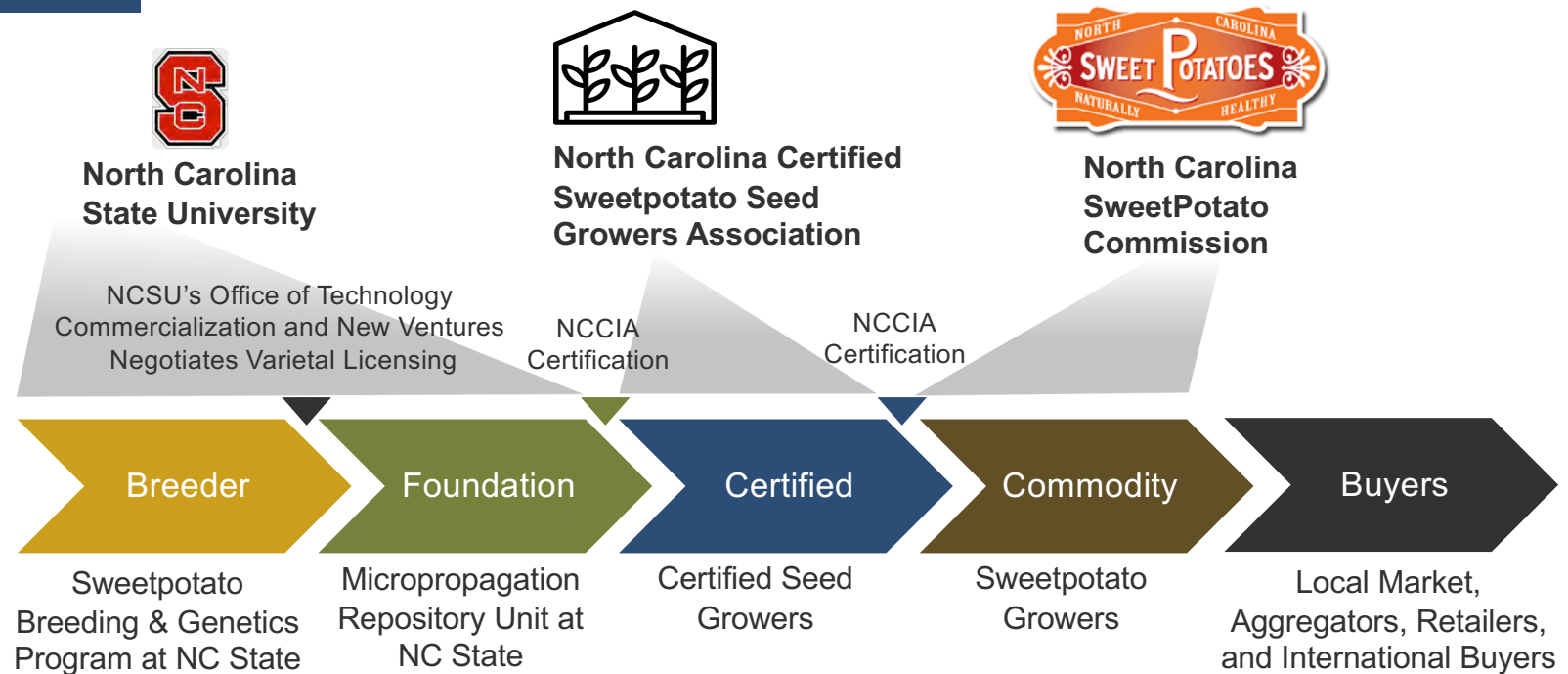
Leadership

LEADERSHIP

Organizational Value Chain Leadership Summary

ORGANIZATION	A	B	C	D	E	F	G
	Sweetpotato Breeding and Genetics Program	N.C. Department of Agriculture & Consumer Services	Micropropagation Repository Unit (MPRU)	N.C. Crop Improvement Association (NCCIA)	North Carolina Sweetpotato Seed Growers Assoc.	North Carolina State Extension	North Carolina SweetPotato Commission
							
	VALUE CHAIN ROLE	MAJOR FUNDING SOURCES	FINANCIAL SUSTAINABILITY				
	<ul style="list-style-type: none"> Varietal development 	<ul style="list-style-type: none"> Research partner that contributes physical and human resources 	<ul style="list-style-type: none"> Foundation seed production and sale 	<ul style="list-style-type: none"> Certification of foundation and commercial seed 	<ul style="list-style-type: none"> Seed grower coordination, advocacy, and oversight 	<ul style="list-style-type: none"> Disseminate research that increases grower profitability and ecological sustainability 	<ul style="list-style-type: none"> Advocate for the interests of North Carolina sweetpotato growers
	<ul style="list-style-type: none"> State funding via university budget allocation Royalty collected on the sale of certified seed Sponsored private sector research Grants 	<ul style="list-style-type: none"> State and federal funding 	<ul style="list-style-type: none"> State funding via university budget allocation Foundation seed sales Cost recovery fee cuttings from foundation seed ('Nuclear Plants') Grants and sponsored private sector research 	<ul style="list-style-type: none"> Certification fees charged for greenhouse and field inspections 	<ul style="list-style-type: none"> Members profit from the sale of certified seed to commercial sweetpotato growers 	<ul style="list-style-type: none"> State funding via university budget allocation 	<ul style="list-style-type: none"> Assessment on sweetpotato growers based on their production acreage (more commonly known as a 'commodity checkoff program')
	PUBLIC SECTOR SUPPORTED, WITH GRANT AND CONTRACT FUNDING	PUBLIC SECTOR SUPPORTED	PUBLIC SECTOR SUPPORTED, WITH GRANT AND CONTRACT FUNDING	FINANCIALLY SUSTAINABLE	FINANCIALLY SUSTAINABLE	PUBLIC SECTOR SUPPORTED. WITH GRANT AND CONTRACT FUNDING	FINANCIALLY SUSTAINABLE

Seed System Overview



Sweetpotato Breeding and Genetics Program at North Carolina State University



Mission:



Develop new sweetpotato and potato varieties

- New varieties must be high yielding, have exceptional appearance and/or processing qualities, and disease and insect resistance



Conduct genetic and breeding research focused on incorporating important and/or new traits into germplasm

- Conventional, specialty, industrial and ornamental types
- Use traditional and genomics-based methods



Assist with the training and professional development of tomorrow's breeders

NC State Sweetpotato and Potato Breeding Team



This team is supported by numerous research station superintendents and staff at the Horticultural Crops Research Station, Central Crops Research Station, Cunningham Research Station, Sandhills Research Station, and Tidewater Research Station

Provide new opportunities for growers today and tomorrow

LEADERSHIP

The North Carolina Department of Agriculture & Consumer Services



North Carolina
Department of Agriculture
& Consumer Services
(NCDA&CS) – Research
Stations Division

MISSION: To manage crop and livestock facilities that serve as a platform for agriculture research to make farming more efficient, productive and profitable, while maintaining a sound environment and providing consumers with safe and affordable products.¹



NCDA&CS has a unique partnership with the North Carolina Agricultural Research Service (NCARS), including co-ownership of the eighteen outlying Research Stations (six managed by NC State and eight by NCDA&CS), and providing the superintendent and farm crew for all eighteen.²

NCDA&CS provides human and physical resources that the Sweetpotato Breeding & Genetics Program relies on to execute demonstration trials and evaluate promising research lines.

This relationship allows the breeding program to stretch its resources, and evaluate more lines than it could do on its own.

Candidate
Evaluation
Fields

Facilities &
Equipment
Management

Research &
Support Staff

Acclimatized
Storage

Micropropagation & Repository Unit at North Carolina State University



The Micropropagation & Repository Unit (MPRU) on the NC State University campus was developed by faculty in the NCSU Departments of Plant Pathology and Horticulture in the 1990's to produce pathogen-free "elite" sweetpotato plants from tissue culture. These 'nuclear plants' must pass certification by the NC Crop Improvement Association (NCCIA) to be sold by the MPRU to the NC Certified Sweetpotato Seed Growers. The seed growers extensively increase production of certified plants (with further NCCIA inspections) to provide annual planting stock for sweetpotato growers statewide.

OBJECTIVE: The Micropropagation & Repository Unit at NCST (MPRU) is responsible for providing virus-tested, true-to-type, asexually propagated sweetpotato planting stock.

KEY RESPONSIBILITIES:

Provide virus testing and pathogen elimination services

Maintain commercial cultivars and advanced selections in the repository

Greenhouse foundation seed production ('nuclear plants')

Coordination of 'nuclear plant' sales to certified seed growers

Conduct research to solve propagation and disease problems

IMPACT: Over 90% of the sweetpotato acreage in NC is planted annually with planting stocks derived from MPRU and the certification program

- Increased yields (~20%) and the overall quality of seed and the commercial crop
- Rapid release of new cultivars & cultivar stability
- Reduced risk of diseases & pests
- Repository for sweetpotato cultivars from NCSU, LSU and USDA-ARS breeding programs.
- Created new opportunities for farm diversification for sweetpotato production

SOURCES OF CAPITAL:

'Nuclear Plant'
Sales \$10 Per
'Nuclear Plant'

Sponsored
Research &
University Funding

Funding From the
Clean Plant
Network

Cost Recovery Fee Based on Number of Greenhouse
Cuttings Made From the 'Nuclear Plants' that are
Purchased \$0.03 Per Cutting



SOURCE: Micropropagation & Repository Unit at NCSU

North Carolina Crop Improvement Association

North Carolina Crop Improvement Association (NCCIA) is non-profit educational and service organization that is responsible for seed certification for 15-20 crops and over 100,000 seed crop acres. NCCIA is funded with fees from Certified Seed Growers

ELEMENTS OF SEED CERTIFICATION:

Validate Source of Seed

- Approved Variety
- Appropriate Class

Inspect/Audit Conditioning Facility

Field Inspection- Visual

- Sq. ft. to sequential sampling
- Diseases, purity, isolation, weeds

Supporting Documentation on Farm-Related Transactions & Agronomic Activities is Available



Issue Tags/Certificates



SOURCES OF CAPITAL

NCCIA is fully funded by seed grower fees from 15-20 crops, and over 100,000 acres of seed crops

SCOPE OF OPERATIONS

Micropropagation Repository Unit at NCSU

10 Greenhouse Nurseries of Nuclear Plant' Cuttings

Field Root Growers (G1 and G2)

- 1,200 hectares
- 20 varieties



North Carolina Sweetpotato Seed Growers Association

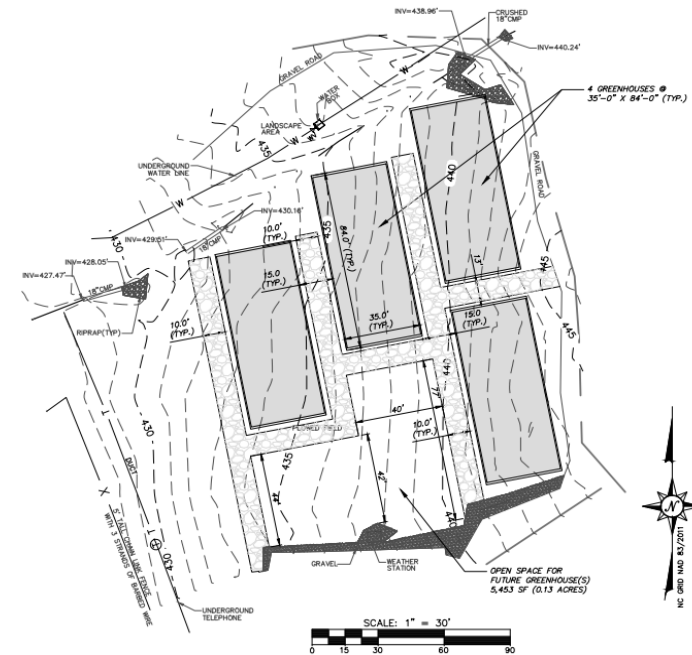
North Carolina Sweetpotato Seed Growers Association is a not-for-profit organization that provides coordination and advocacy on behalf of the 10-15 certified sweetpotato producers in the State

Certified seed growers compete, but have a common interest in the demand for certified seed, and the supply of foundation seed.

The Association, and its membership, work closely with the Sweetpotato Breeding & Genetics Program and NCCIA, and hold semi-annual meetings to review and decide on issues of importance.

A key recent decision made by the Association was to increase the cost recovery fee per vine propagated from 'Nuclear Plants' (foundation seed), by \$0.05, to fund the construction of dedicated greenhouse facilities for the Micropropagation Repository Unit at North Carolina State University.

New Sweetpotato Greenhouse Project



LEADERSHIP

North Carolina State Extension

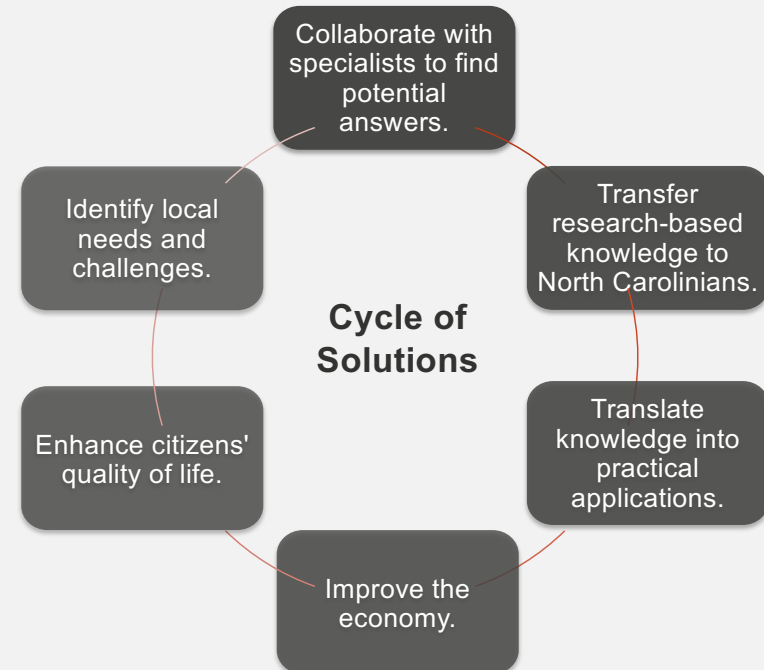
North Carolina is home to two land-grant institutions – NC State University and N.C. A&T State University. Land-grant universities have a unique and important obligation to serve our state through Extension. It's what sets us apart from other universities.



Each school coordinates Extension programs that work in collaboration with the U.S. Department of Agriculture's National Institute of Food and Agriculture (USDA-NIFA), as well as state and local governments. This strategic partnership is called N.C. Cooperative Extension.

NC STATE UNIVERSITY

NC State Extension faculty and staff work throughout the spectrum of innovation to deliver research-based solutions to local issues.

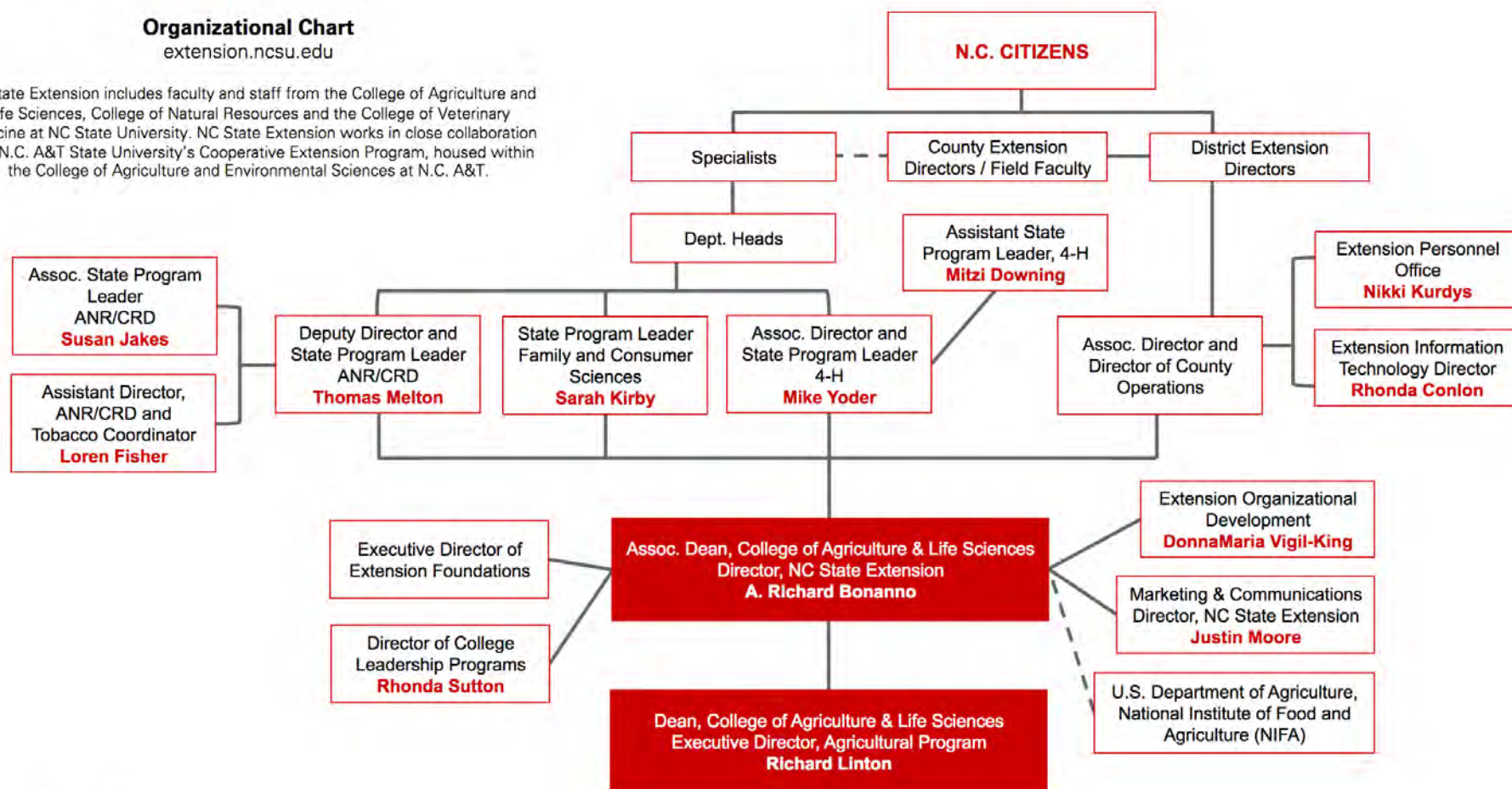


NC STATE EXTENSION



Organizational Chart extension.ncsu.edu

NC State Extension includes faculty and staff from the College of Agriculture and Life Sciences, College of Natural Resources and the College of Veterinary Medicine at NC State University. NC State Extension works in close collaboration with N.C. A&T State University's Cooperative Extension Program, housed within the College of Agriculture and Environmental Sciences at N.C. A&T.



Updated January 2018

SOURCE: NC State Extension

The NC SweetPotato Commission Markets North Carolina Sweetpotatoes & Funds Breeding Program Initiatives ^G



The NC SweetPotato Commission Funds Itself with Annual Assessments, also known as Check-Off Funds, that Sweetpotato Growers Pay Based on Their Production Acreage. In 2017, the assessment was **\$15 acre**.

The North Carolina SweetPotato Commission Inc. is a nonprofit corporation made up of over 400 sweetpotato growers along with the packers, processors and business associates that support them. The sole purpose of the commission is to increase sweetpotato consumption through education, promotional activities, research and honorable horticultural practices among its producers.



“Our goal is to have more restaurant promotions here in North Carolina and in target markets to continue this process,” Daughtry said. “The more restaurants serving sweetpotatoes, the more consumers will consider sweetpotatoes in more ways, more often.” – Coco Daughtry, Communications Specialist (2017)¹

(1) SOURCE: [N.C. commission emphasizes year-round 'sweetness'](#) by David Mitchell, The Pack (2017)



Research & Varietal Development

Sweetpotato Breeding and Genetics Program at NC State Overview (Cont.)

The Sweetpotato Breeding and Genetics program works with thousands of different lines each season

OPERATIONS

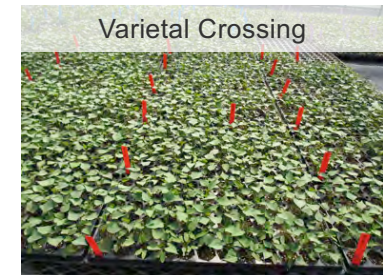
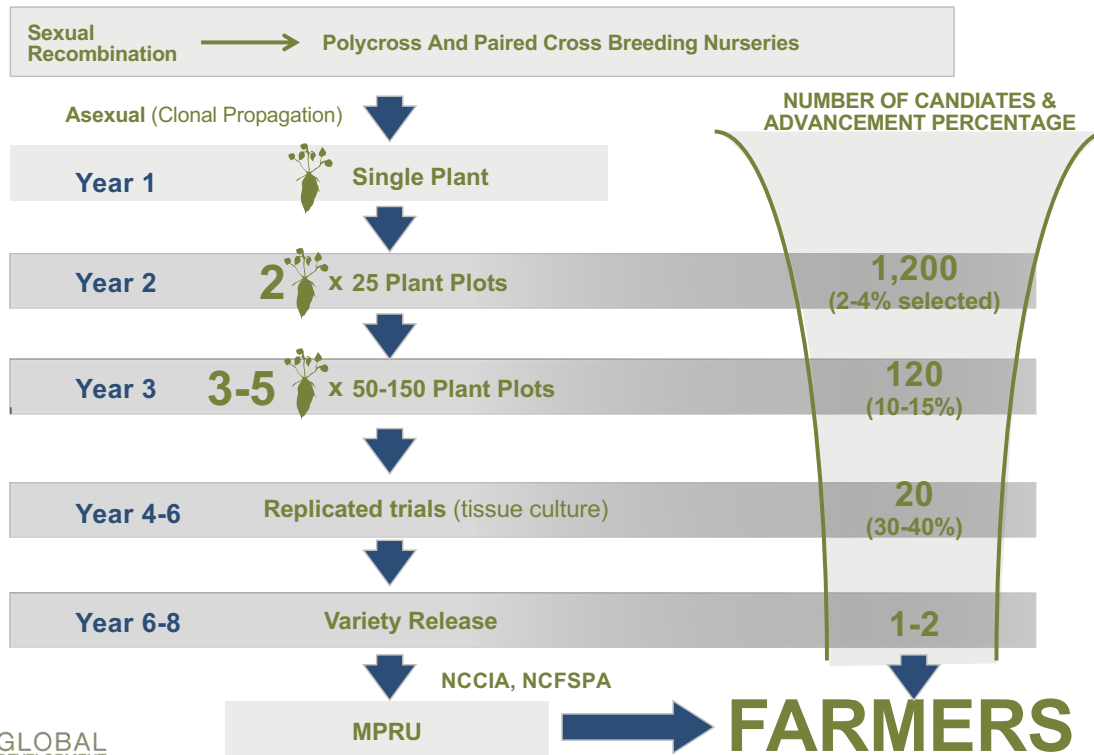
NCSU produces over 100,000 botanical seed, and plant 55,000 sweetpotato seed annually. This seed comes from both field nurseries and paired crosses in the greenhouse. Each flower crossed in the greenhouse is completed by hand and then marked by hand with a label indicating the parents. Once the seed capsule is mature, it is harvested, processed, and stored until it is ready to be planted.

Sweetpotatoes are stored in large racks contained in climate controlled rooms over the winter in preparation for the next season. In the spring, these roots are bedded (planted) over three acres at the Horticulture Crops Research Station in Clinton, NC and used as stock plants for research all over the state.



New Varietal Development & Release Requires ~8 Years

Sweetpotato Variety Development Process – NC State



Grower Participatory Breeding

A key feature of NC State's breeding program is its engagement with 6-8 select growers to evaluate promising varieties in on-farm trials across multiple environments, before they are released.

Pros:

Collect diverse, on-farm observations at a lower cost than if solely managed by NCSU's breeding program

Bulk up production early to eliminate 1-2 years or bulking that would be required after a variety is released

Engaged feedback with certified seed growers provides insight into the potential features, attributes, and benefits of new varieties

Cons:

Cleanup required if a pre-release variety is distributed to growers, but is never released

Risk and cost to certified seed growers who bulk up seed production of a promising variety that never gets released



SOURCE: Sweetpotato and Potato Breeding and Genetics Programs

Farmer Participatory Breeding Strengthens the Relationship Between Breeder and Grower, Hastens Varietal Speed to Market, Enables Bulking Prior to Release, and Stimulates Demand & Adoption

Breeding Program Leverages the Resources of the North Carolina Department of Agriculture to Maximize its Budget

On-Site Field Trials and Storage is Done at NC Department of Agriculture Research Stations

Plant



Cultivate



Harvest



Store



Evaluate



PHOTO SOURCE: Sweetpotato and
Potato Breeding and Genetics Programs

Mechanization of Researchers Field Activities

Two Row Sweetpotato Transplanter



Sweetpotato Storage Root Harvester



Sweetpotato Fries Are A Driver of Change in North Carolina's Sweetpotato Industry

To Evaluate Varieties' Suitability for Sweetpotato Fries and Potato Chips, Fry Tests Are Conducted on the "Best Clones" from 2nd Year Selections





Demand Planning & Operations

Operational Overview by Seed System Function

VARIETAL DEVELOPMENT & SEED DEPLOYMENT



Varietal Development

NC States' Sweetpotato Breeding and Genetics Program manages all varietal development activities. Breeders work with thousands of different lines each season, and engage with growers to evaluate and bulk up promising pre-release varieties.



Seed Multiplication

NC State's Micropropagation Repository Unit (MPRU) is charged with virus indexing, breeder seed maintenance, tissue culture multiplication, greenhouse foundation seed production, and distribution of foundation seed to certified seed growers.



Certified Seed Production

Certified seed growers purchase Nuclear Plants (G0) from the MPRU for multiplication into G0, G1, and G2 cuttings and roots for sale to commercial growers, and incorporation into their own integrated commercial farming operations. The North Carolina Crop Improvement Association (NCCIA) manages the sweetpotato certification process.

FARMER PRODUCTION, MARKETING, AND KEY DEMAND SEGMENTS



Farm Production

Commercial growers, who are often times also certified seed growers, plant G2 roots for the production of sweetpotatoes that are harvested, cleaned, and sorted on-farm. Commercial growers are large, planting between 500 to 30,000 acres. They enter into direct sales contracts with wholesalers and grocers. Premium roots, known as '#1s', are sold whole. Non-premium roots are sold into the processors' value-chain.



Industry Advocacy

The North Carolina SweetPotato Commission Inc. is a nonprofit corporation made up of over 400 Sweetpotato growers along with the packers, processors and business associates that support them. The sole purpose of the commission is to increase sweetpotato consumption through education, promotional activities, research and honorable horticultural practices among its growers. The NC Foundation Seed Producers is the nonprofit entity charged with foundation seed production across all commodities in the state.



Demand Segments

An estimated 70% of sweetpotatoes grown in North Carolina are sold directly to chain stores, terminal market facilities, or foodservice providers. The remaining 30% is sold to processors for canning, flaking, chipping, frying, freezing or baby food. Ratio is likely to shift toward processing into the future.

ENABLING ENVIRONMENT STAKEHOLDERS

[NCSU College of Agriculture and Life Sciences](#)

[NCSU Department of Horticultural Science](#)

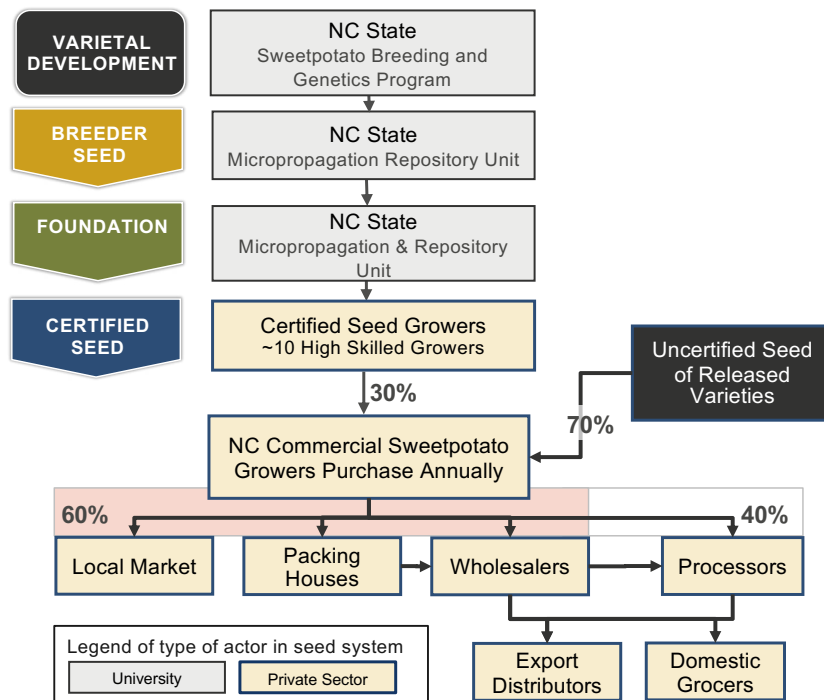
[National Clean Plant Network](#)

[NCFSPA](#)

[USDA](#)

NC Sweetpotato EGS System Overview

Seed Deployment Schematic



BREEDER SEED

10K

PROPOGATED
NUCLEAR SEED IN
TISSUE CULTURE

The Sweetpotato Breeding and Genetics Program provides newly released varieties to the MPRU for virus indexing and propagation. The MPRU provides virus-tested, true-to-type, asexually propagated sweetpotato planting stock that underpin the commercial seed system. It maintains commercial cultivars and advanced selections in its repository, provides virus testing and pathogen elimination services, and conducts research to solve propagation and disease problems.

FOUNDATION

10K

NUCLEAR
PLANTS

The MPRU manages the production and distribution of Nuclear Plants (foundation seed) to Certified Seed Growers in the state. The number of Nuclear Plants distributed by the MPRU has increased from ~2,500 in 1998/99 to over 10,500 in 2016/17. A new requirement, as of 2016/17, is that all Nuclear Plants distributed must be produced from Tissue Culture versus from propagation of Nuclear Plants. This measure is intended to strengthen quality control, by minimizing production variance.






CERTIFIED SEED

3.5 M

'ELITE PLANTS'
PROPOGATED
FROM 'NUCLEAR
PLANTS'

Certified Seed Growers utilize greenhouses to propagate and plant G0 plants for the production of G1 and G2 roots. An estimated 1,200 hectares are planted with G0 and G1 planting material for the cultivation of G1 and G2 roots in North Carolina. G2 roots are either sold to growers, or planted by vertically integrated certified seed growers for the production of sweetpotatoes.

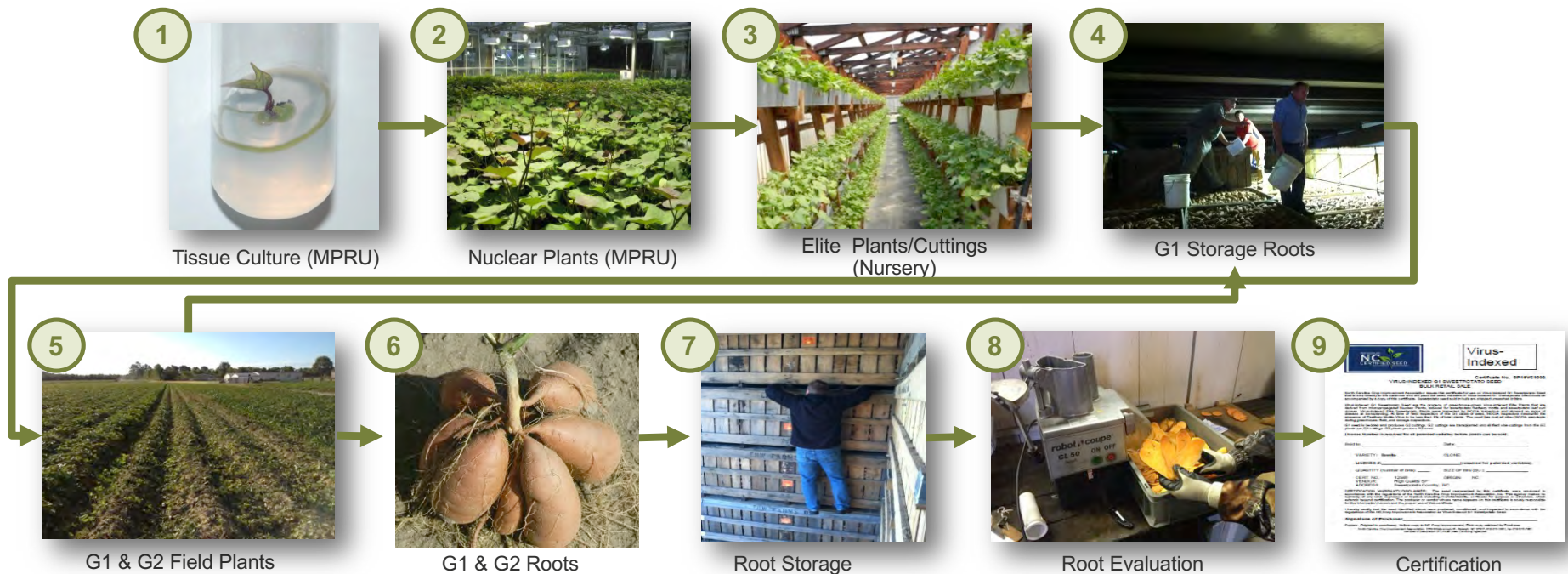
Early Generation Seed Deployment Model

	Breeder Seed		Foundation Seed	Certified Seed	Sweetpotatoes
Who:	North Carolina State University Micropropagation and Repository Unit			10-15 Certified Seed Growers in NC	125-150 NC Growers Purchase Certified Material Annually
Sector:	PUBLIC			PRIVATE	PRIVATE
Input:	1,000 Meristem-Tip Culture True-to Type Virus Tested Nuclear Seed		10,000 Rooted Breeder Seed from Tissue Culture	10,000 Elite Plants (G0)	3,500,000 G1 and/or G2 Plants & Roots
Output:	10,000 Propagated Breeder Seed in Tissue Culture Tissue Culture 		10,000 Nuclear Plants 6ft Nuclear Plants 	3,500,000 Elite Plants & Cuttings (G0) Elite Plants/Cuttings  G1 & G2 Plants & Roots 	+80,000 Acres of Sweetpotato Production Commercial Production 
Capital Sources:	Annual Certified Seed License Fee to University Funding from the Clean Plant Network		Nuclear Plant Sales Revenue to MPRU NC Sweetpotato Commission Support to MPRU	Cost Recovery Fee Calculated Based on the Number of Planting Material Propagated from Nuclear Plants Sale of Certified Seed	Sale of Sweetpotatoes

SOURCE: Sweetpotato and Potato Breeding and Genetics Programs

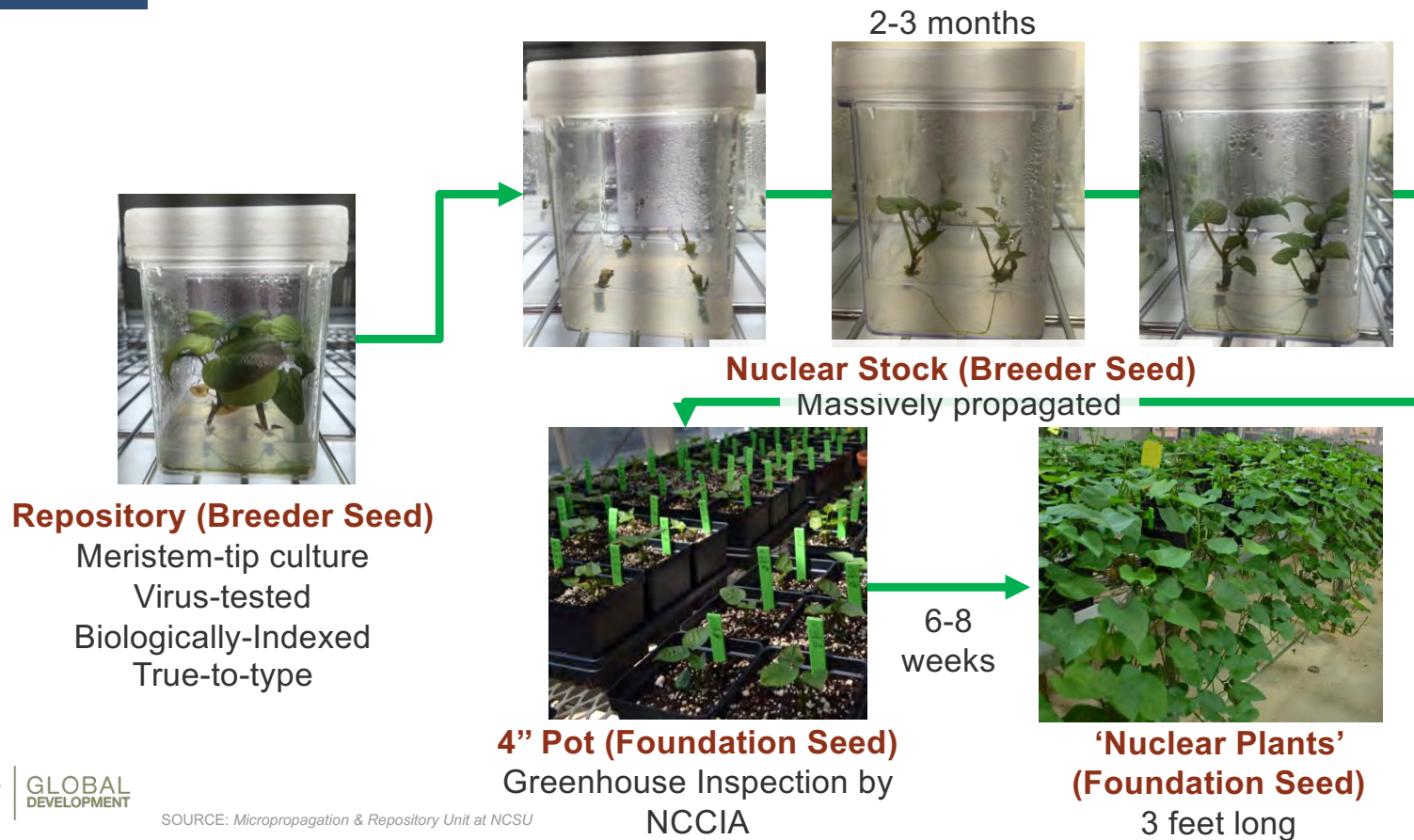
Sweetpotato Seed Certification Process Flow Overview

The North Carolina Crop Improvement Association Leads Quality Control and Seed Certification Function for NC Sweetpotatoes



SOURCE: North Carolina Crop Improvement Association

MPRU's Tissue Culture Production System for Production of Nuclear Plants (Foundation Seed)



MPRU's Acclimatized Tissue Culture Nuclear Stock Storage Room



SOURCE: Micropropagation & Repository Unit at NCSU

Early Stage 'Nuclear Plants' From Tissue Culture in Production Greenhouse



Photos of Foundation Seed ('Nuclear Plant') Growth Over Time



'Nuclear Plants' at 3-4 Weeks



'Nuclear Plants' at 8 Weeks

In 2017 Certified Seed Growers Pre-Ordered Their 'Nuclear Plants' Two to Nine Months Before Pickup

Grower	Date Ordered	Date Picked up
1	07/15/17	09/15/17
2	02/01/17	10/31/17
3	10/28/17	12/01/17
4	07/20/17	12/21/17
5	08/30/17	12/22/17
6	11/29/17	01/23/18
7	11/11/17	01/26/18
8	11/29/17	01/31/18
9	11/03/17	02/01/18
10	11/20/17	02/08/18
11	12/07/17	02/14/18



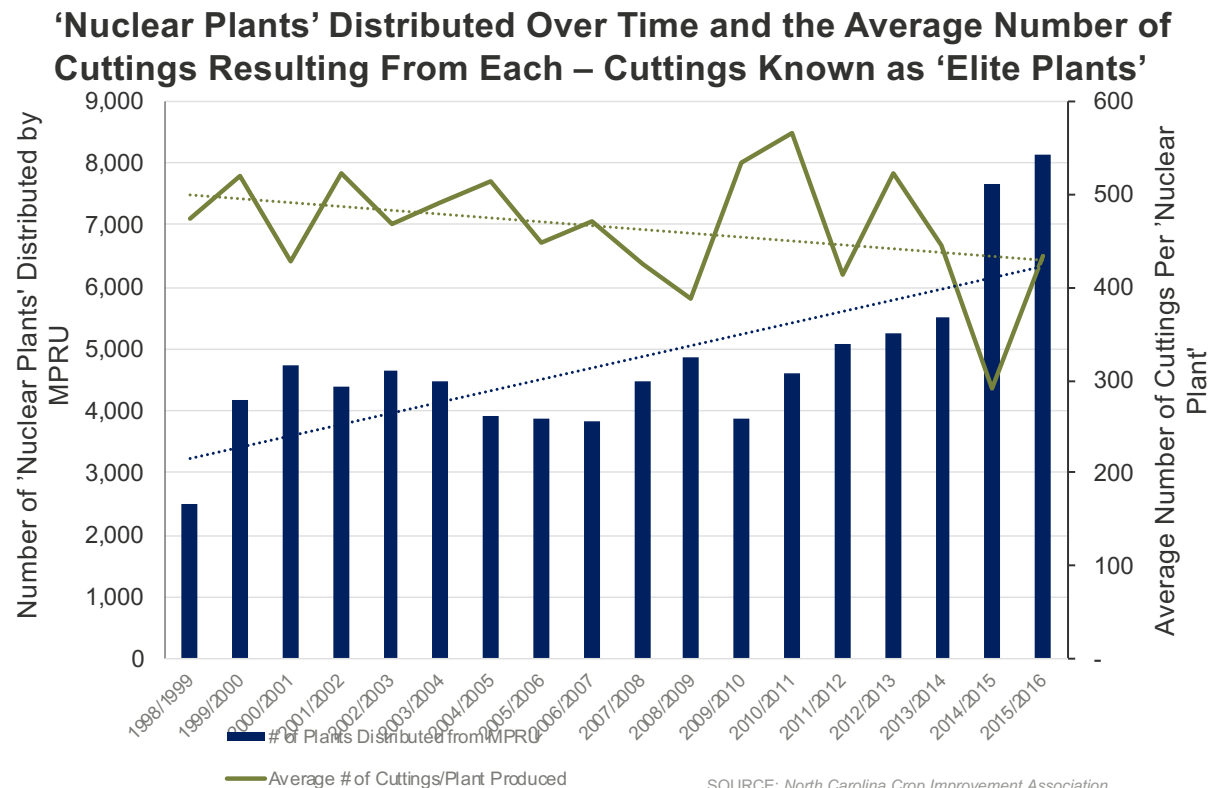
MPRU Produces & Sells Foundation Seed 'Nuclear Plants' to Certified Seed Growers For Propagation into 'Elite Plants' in their Greenhouses

TAKEAWAYS:

MPRU Sells 'Nuclear Plants' to 8 to 11 Certified Seed Growers Annually

Elite Vine Distribution Increased 228% Between 1998/99 and 2015/16

An Average of 433 Cuttings Were Recorded From Each 'Nuclear Plant' in 2016



Certified Seed Growers

CERTIFIED SEED PRODUCTION OVERVIEW

Certified seed growers purchase 'Nuclear Plants' (G0) from the MPRU for multiplication into G0, G1, and G2 cuttings and roots for sale to commercial growers and incorporation into their own integrated commercial farming operations.

EXPENSES:

Operational & Investment Costs for Greenhouse & Field Management, Labor, Storage, Equipment, Storage, Transportation, Sales & Marketing

\$1,500 Annual License for the Right to Sell Proprietary Seed of NCST Patented Varieties

\$0.03 Per Cutting that Certified Seed Producers Make From 'Nuclear Plants' Purchased from the MPRU

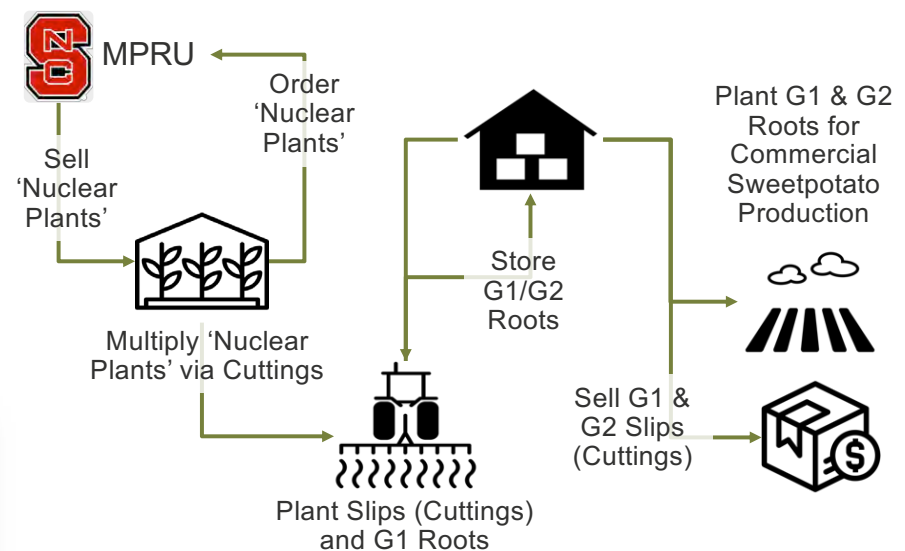
5% Royalty on the Value of Certified Seed Sold Within the State (10% out of State) Remitted to NCSU

REVENUE:

Sale of Certified Seed, Mostly in the Form of Roots



BUSINESS MODEL SCHEMATIC:



Certified Seed Growers Have Leveraged Rapid Propagation Technology to Increase 'Nuclear Plant' (Foundation Seed) Multiplication

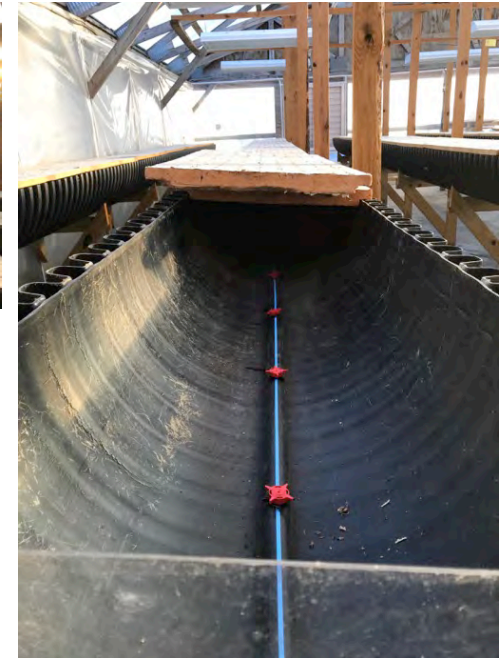
Jones Family Farms is a certified seed and plant wholesaler, selling to producers all over the U.S. and Canada. Since he started in the mid-1990s with micropropagation, Jones has become one of the largest suppliers of sweetpotato cuttings in the Southeast – Jones Family Farms

Jim Jones
pictured with his
custom designed
and constructed
Aeroponics
System



Link to AGCO video on
Jim Jones' Operations

<https://www.youtube.com/watch?v=70t8e9e9e9e9>



"We've been buying sweetpotato plants and seed stock from Jim Jones for six years. All the varieties I've purchased from him have been true-to-type – an excellent and necessary step to growing a great crop of sweetpotatoes." – **a 500-acre Johnston Co., NC sweetpotato grower**

Post-Harvest Transportation, Seed Storage, and Packaging at Jones Family Farms



Transportation



Modified school buses are used to hasten post-harvest transportation from the field to the storage facility



Certified Seed Storage



Certified seed is stored in slotted, wooden bins inside of a dry, unconditioned warehouse with natural ventilation



Packaging



The minimum order weight for certified seed is 40 lbs.



Jones Family Farms Ships Certified Seeds of Nine Sweetpotato Varieties to Growers in the USA & Canada



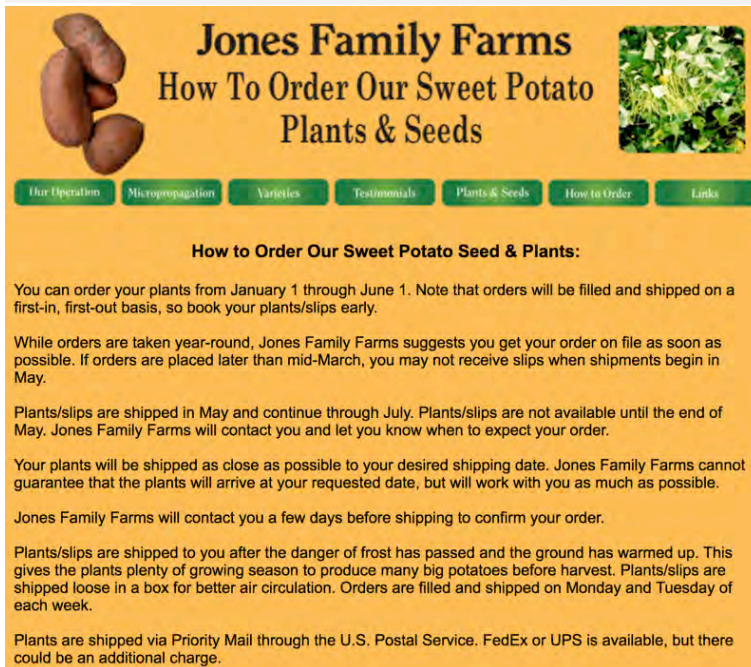
Online Ordering Form



Packaging



Certified Seed Storage



Jones Family Farms
How To Order Our Sweet Potato Plants & Seeds

[Our Operation](#) [Micropropagation](#) [Varieties](#) [Testimonials](#) [Plants & Seeds](#) [How to Order](#) [Links](#)

How to Order Our Sweet Potato Seed & Plants:

You can order your plants from January 1 through June 1. Note that orders will be filled and shipped on a first-in, first-out basis, so book your plants/slips early.

While orders are taken year-round, Jones Family Farms suggests you get your order on file as soon as possible. If orders are placed later than mid-March, you may not receive slips when shipments begin in May.

Plants/slips are shipped in May and continue through July. Plants/slips are not available until the end of May. Jones Family Farms will contact you and let you know when to expect your order.

Your plants will be shipped as close as possible to your desired shipping date. Jones Family Farms cannot guarantee that the plants will arrive at your requested date, but will work with you as much as possible.

Jones Family Farms will contact you a few days before shipping to confirm your order.

Plants/slips are shipped to you after the danger of frost has passed and the ground has warmed up. This gives the plants plenty of growing season to produce many big potatoes before harvest. Plants/slips are shipped loose in a box for better air circulation. Orders are filled and shipped on Monday and Tuesday of each week.

Plants are shipped via Priority Mail through the U.S. Postal Service. FedEx or UPS is available, but there could be an additional charge.



Jones Family Farms is a certified seed and plant wholesaler, selling to producers all over the U.S. and Canada. Since he started in the mid-1990s with micropropagation, Jones has become one of the largest suppliers of sweetpotato cuttings in the Southeast.



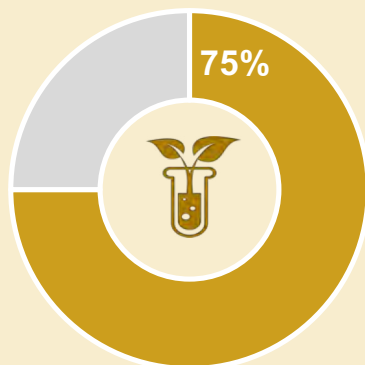
SOURCE: Jones Family Farms



Financial Sustainability

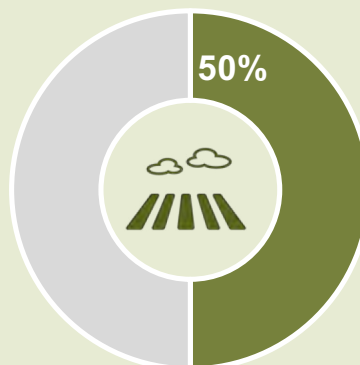
Financial Sustainability by EGS Value-Chain Step

Varietal Development



Sponsored Research, Grants, and Royalties Account for 75% of the Breeding Program's Operating Costs; The Public Sector Funds the Other 25%

Foundation Seed Production



Public Sector Supports 50% of Operating Costs; Private Seed Producers Fund the Other 50% Through Foundation Seed Purchases and a Cost Recovery Fee Based on Propagation

Certified Seed Production



Seed Growers Fund Certified Seed Production Through Seed Sale Revenue

Varietal Development is Largely Self-Funded Through Sponsored Research & Competitive Grants

Private Sector Funding

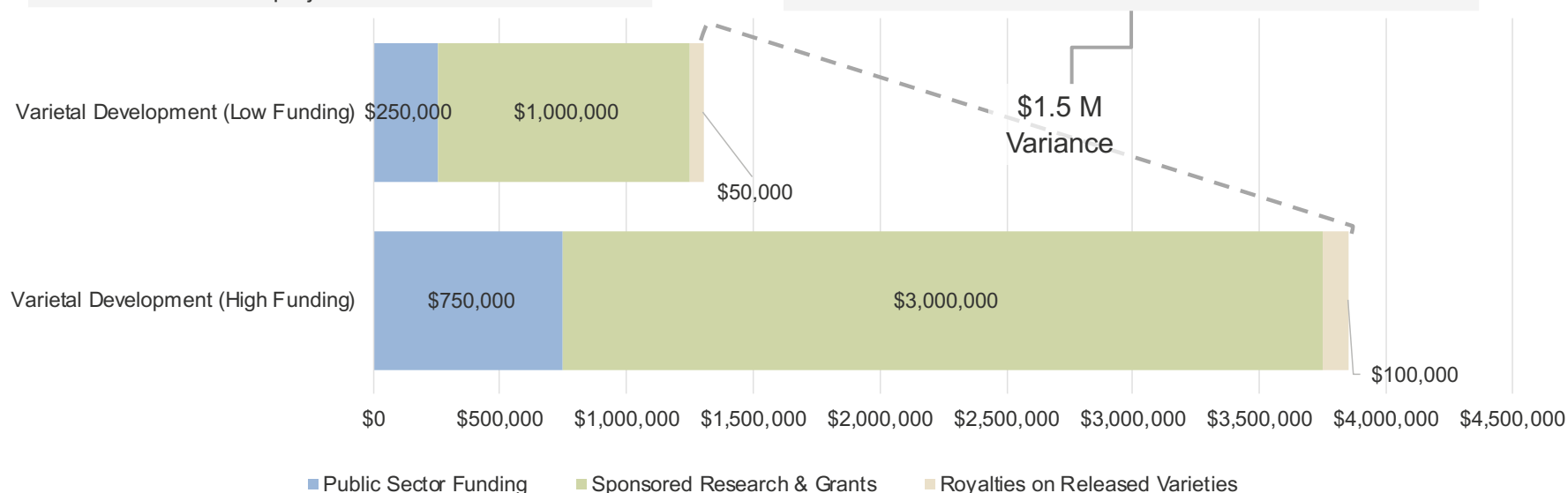


Private sector funds research through the allocation of checkoff funds and sponsored research projects

Budget Variability

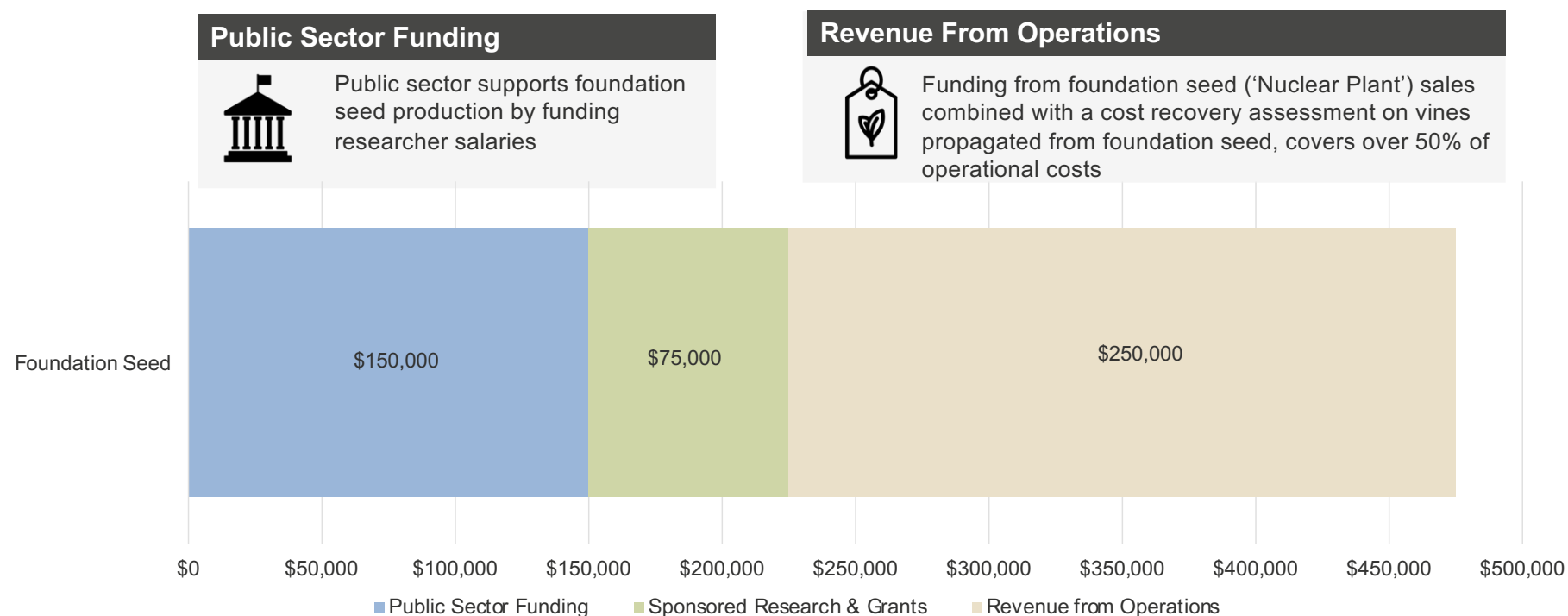


Funding for varietal development is variable because of the reliance on sponsored research and grants, which can be unpredictable



Royalties on the sale of certified seed of NC State varieties, and revenue from foundation seed sales, fund but a fraction of the operating costs associated with varietal development and foundation seed production

Foundation Seed Production is Largely Subsidized by the Public Sector



Early Generation Seed Subsidization Enables Profitable Certified and Commercial Sweetpotato Production



10-15 certified seed growers purchase and multiply foundation seed for the production and sale of certified seed that supplies an estimated 30% of North Carolina acres annually



Over 90% of the sweetpotato acreage in NC is planted annually with planting stocks derived from MPRU and the certification program



Commodity Association Collects an Acreage Assessment on Sweetpotato Growers

In January 2016, a continuing referendum was conducted to allow sweetpotato growers and producers to assess themselves an amount of \$15/acre. This assessment will be for six years and the vote passed, unanimously. In accordance with the referendum results, the NC SweetPotato Commission will invoice all producers, based upon USDA crop certification data. – The North Carolina SweetPotato Commission, Inc.

Commodity Assessment Policies

- 1 Sweetpotato producers shall certify all planted sweetpotato acres (seed, commercial, charitable, livestock/wildlife or home usage), to the Farm Service Agency in the county in which the acreage is located.
- 2 Unless stated to the contrary at the time of certification, the operator of a farm shall be considered as the producer.
- 3 The final date for certification of sweetpotato acreage is July 15 of each year.
- 4 The North Carolina SweetPotato Commission shall send by mail to all known sweetpotato producers an Annual Assessment notice and a NCDA&CS form entitled Report of Commodity Assessment to be used by the producer to report the correct total acreage of sweetpotatoes planted (1.0 acres or more). Invoicing shall occur on or before October 15 annually.
- 5 All assessments are due on November 15 of each year.
- 6 The producer shall remit to the NCDA&CS the proper amount of assessments due (total number of planted acres @ the rate of \$15.00 per acre), and the farm serial numbers and/or landlords using the NCDA&CS form. The check and form shall be mailed to: NC Department of Agriculture & Consumer Service Division of Marketing Attn: Rachel Holly PO Box 27647 Raleigh, NC 27611.
- 7 Any producer who fails to pay assessments by January 1 of each year, shall also pay a penalty of ten percent (10%) of the unpaid assessment, plus interest at the rate of one percent (1%) of the unpaid assessment balance for each month the assessment remains unpaid.
- 8 If an assessment remains unpaid 60 days after the due date of November 15, the North Carolina SweetPotato Commission shall take any action deemed appropriate by the Board of Directors to recover unpaid assessments, penalties and the reasonable costs of such action, including attorney and court fees.
- 9 There will be no refunds of assessments paid.
- 10 No exemption of assessments due will be granted to any producer receiving loss payments from Noninsured Assistance Program (Farm Service Agency NAP), and/or sweetpotato Disaster Relief Programs.



Enabling Environment

Licensing of NC State Sweetpotato Varieties

TECHNOLOGY TRANSFER

**NC STATE
UNIVERSITY**

The Office of Technology Commercialization and New Ventures at NC State manages licensing agreements on behalf of the inventor



Historically, new varieties are licensed on a two-year exclusive agreement to the NC Sweetpotato Commission

After two years, NC State can license the variety to out-of-state licensees

After four years, NC State can license the variety to international licensees

SWEETPOTATO ROYALTIES

Currently, royalties are assessed on sweetpotato seed sales. In the future, it is expected that royalties will be assessed on sweetpotato acres as is done with check-off assessments to the NC Sweetpotato Commission

In-state royalty: 5%

Out-of-state royalty percentage: 10%

20% of the Royalties Collected on NC State Licenses Varieties is Retained by The Office of Technology Commercialization to fund its operations

U.S. Land-Grant Institution Overview

Mission:

“Teach such branches of learning as are related to agriculture and the mechanic arts . . . in order to promote the liberal and practical education of the industrial classes.” – Morrill Act 1862

U.S. Land-Grant Universities Were Founded Based on Three Principle Functions, Which Continue to Drive Them Today :

Teaching



The First Morrill Act (1862) provided grants in the form of federal lands to each state. States sold these lands and established public institutions with the proceeds. The goal of land-grant universities was initially to meet the increasing demand for agricultural and mechanical education. Currently, land-grant universities continue to offer education programs centered on agriculture and engineering.

Research



The Hatch Act (1887) authorized direct payment of federal grants to each state to establish agricultural experiment stations. Funding remains in place today for these programs. A major portion of federal funds invested must be matched by state funding.

Cooperative Extension



The Smith-Lever Act (1914) created the Cooperative Extension Program within each land-grant institution to disseminate research findings from the agricultural experiment stations. The act authorized ongoing federal support (matched by state support) for the Cooperative Extension Systems, which still exists for extension programs today.

The USDA plays a large role in the allocation of funds for each function of the U.S. land-grant university system. These funds are essential to assure that the functions of the universities can continue to benefit all industries, including the agricultural industry.

“The Morrill Act symbolizes the public trust that has given life to our nation's entire educational system for the past 150 years—and it reminds us all of the public commitment that will be necessary for the system to thrive for 150 more.”

–**Christopher P. Loss, Vanderbilt University**

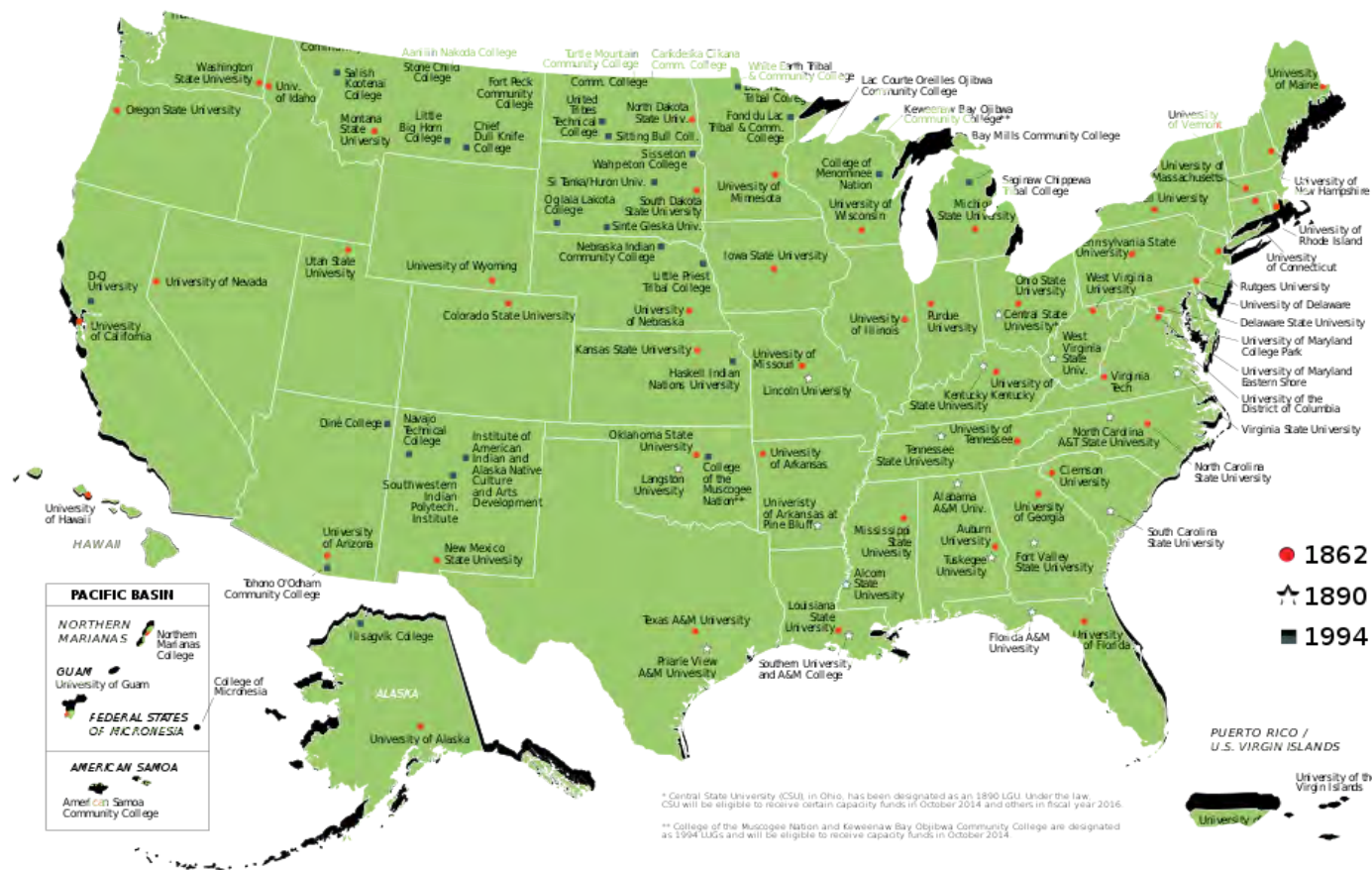
Land-Grant Colleges and Universities in the United States



United States
Department of
Agriculture

National Institute
of Food and
Agriculture

NIFA LAND-GRANT COLLEGES AND UNIVERSITIES



The NC Seed Industry Is Subject to State and Federal Law

INTERSTATE & FOREIGN

Federal Seed Act

An Act to regulate interstate and foreign commerce in seeds; to require labeling and to prevent misrepresentation of seeds in interstate commerce; to require certain standards with respect to certain imported seeds; and for other purposes. ¹

NORTH CAROLINA

The North Carolina Seed Law of 1963





The purpose of this Article is to regulate the labeling, possessing for sale, sale and offering or exposing for sale or otherwise providing for planting purposes of agricultural seeds and vegetable seeds; to prevent misrepresentation thereof; and for other purposes. ²



Primary to ASTA's state legislative agenda is to ensure that state regulations relating to the seed industry remain consistent between the states. This allows for smoother interstate trade, equalized competition, and elimination of unnecessary, duplicative and burdensome regulations. The Recommended Uniform State Seed Law (RUSSL) is the preferred model for state seed regulations.³

(1) SOURCE: United States. Cong. House. Committee on Agriculture. *Federal Seed Act, P.L. 76-354*. 76th Congress. H. Rept. 5625.. 4 February, 1940.
(2) SOURCE: North Carolina Seed Law of 1963, (1941, c.114, s.1;1945, c. 828; 1949, c. 725; 1963, c.1182.), Article 31.
(3) SOURCE: "State." ASTA. N.p., n.d. Web. 05 Apr. 2018.

Overview of Federally Subsidized Agriculture Risk Management Mechanisms

FUNCTION	DETAIL
 <p>National Commodity Price Hedge</p>	<p>Price Loss Coverage (PLC): 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.</p>
 <p>Regional Commodity Price Hedge</p>	<p>Agriculture Risk Coverage (ARC): 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.</p>
 <p>Commodity Marketing Credit</p>	<p>Marketing Assistance Loan Program: 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.</p>
 <p>National Crop Insurance</p>	<p>Traditional crop insurance: 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.</p>

SOURCE: [USDA ERS](#)

Plant Variety Protection in the United States

The Plant Variety Protection Office (PVPO) provides intellectual property protection to breeders of new varieties of seeds and tubers. Implementing the [Plant Variety Protection Act](#) (PVPA), we examine new applications and grant certificates that protect varieties for 20 years (25 years for vines and trees). Our certificates are recognized worldwide and allow faster filing of PVP in other countries. Certificate owners have rights to exclude others from marketing and selling their varieties, manage the use of their varieties by other breeders, and enjoy legal protection of their work¹.

In the U.S. there are 3 types of intellectual property protection that breeders can obtain for new plant varieties:

	1 Patent Law ("Utility" or Invention)	2 Plant Patent Law	3 Plant Variety Protection Law
Applicable to:	Plant, plant part, gene, protein, method, etc.	Asexually propagated plant and its asexually propagated progeny	Sexually (seed) propagated plant varieties
Rights to Exclude Others From:	Making, using, selling, offering for sale and importing the plant, or any of its parts	Making, using, selling, offering for sale and importing the plant, or any of its parts	Selling, marketing, conditioning, stocking, offering for sale, reproducing, importing, or exporting, using the variety to produce (as distinguished from develop) a hybrid or different variety
Terms of Protection:	20 year term from date of filing	20 year term from date of filing	20 year term (25 years for trees or vines) from issuance of the certificate
Exemption:			A person (grower) may save seeds for planting on the person's land, but may not transfer to others for seed reproduction purposes

(1) SOURCE: "Plant Variety Protection." *Plant Variety Protection* | Agricultural Marketing Service, www.ams.usda.gov/services/plant-variety-protection.
 (2) SOURCE: Calvert, J. (2014). Impact of Plant Variety Protection [PowerPoint slides]. Retrieved from <http://slideplayer.com/slide/751825/>.



Appendix

ACKNOWLEDGEMENTS



Thank You For
Your Time
& Support in
the Development
of the NC
Sweetpotato
EGS Profile

Key Stakeholders Interviewed

Name	Position	Organization
Dr. Christie Almeyda	Director	Micropropagation Repository Unit at NCSU
Dr. Roger Crickenberger	Special Project Manager	North Carolina State University
Dr. William “Bill” Foote	Executive Director	North Carolina Crop Improvement Association
Jim Jones	Owner	Jones Family Farms
Ken Pecota	Senior Research Scholar	Sweetpotato Breeding & Genetics Program at NCSU
Dr. Craig Yencho	Program Leader	Sweetpotato and Potato Breeding & Genetics Program at NCSU

thank you



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Research Spotlight: “Cultivar Development in the U.S. Public Sector” – Shelton, A. C., and W. F. Tracy. 2017

192 US-Based Plant Breeders Responded to a Survey in 2015 on Key Industry Questions



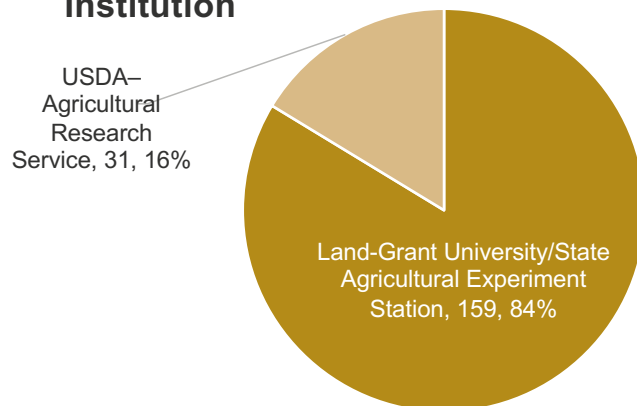
Abstract: Public plant breeders at land grant universities and USDA play a critical role in the development of improved cultivars for growers in the United States. Over the past 20 yrs, a series of reports have documented the decrease in public plant breeding programs, breeder positions, and government 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.



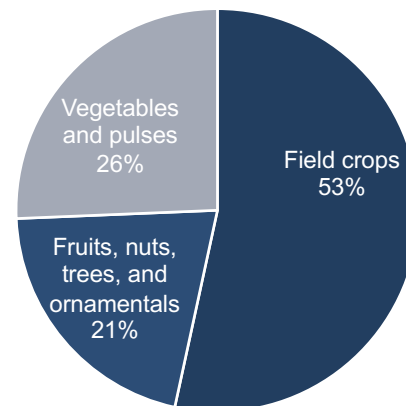
Conclusion: Public plant breeders play a critical role in determining the future of agriculture. Their work is varied, and includes long-term research in areas such as assessing and broadening genetic diversity, introgression of traits from wild species, development of new breeding methodologies, and 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...

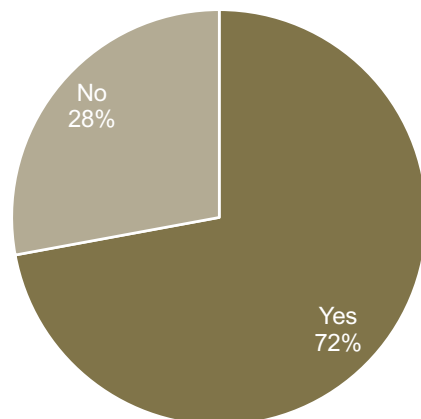
Institution



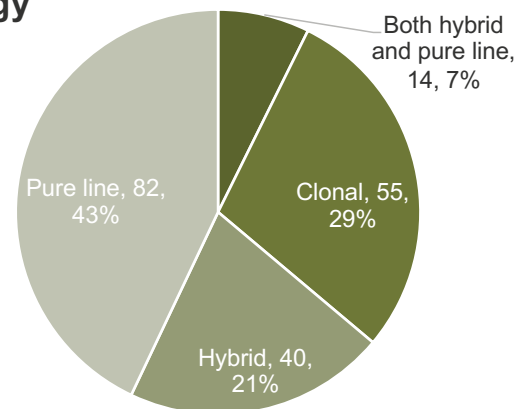
Crop Type



Tenure

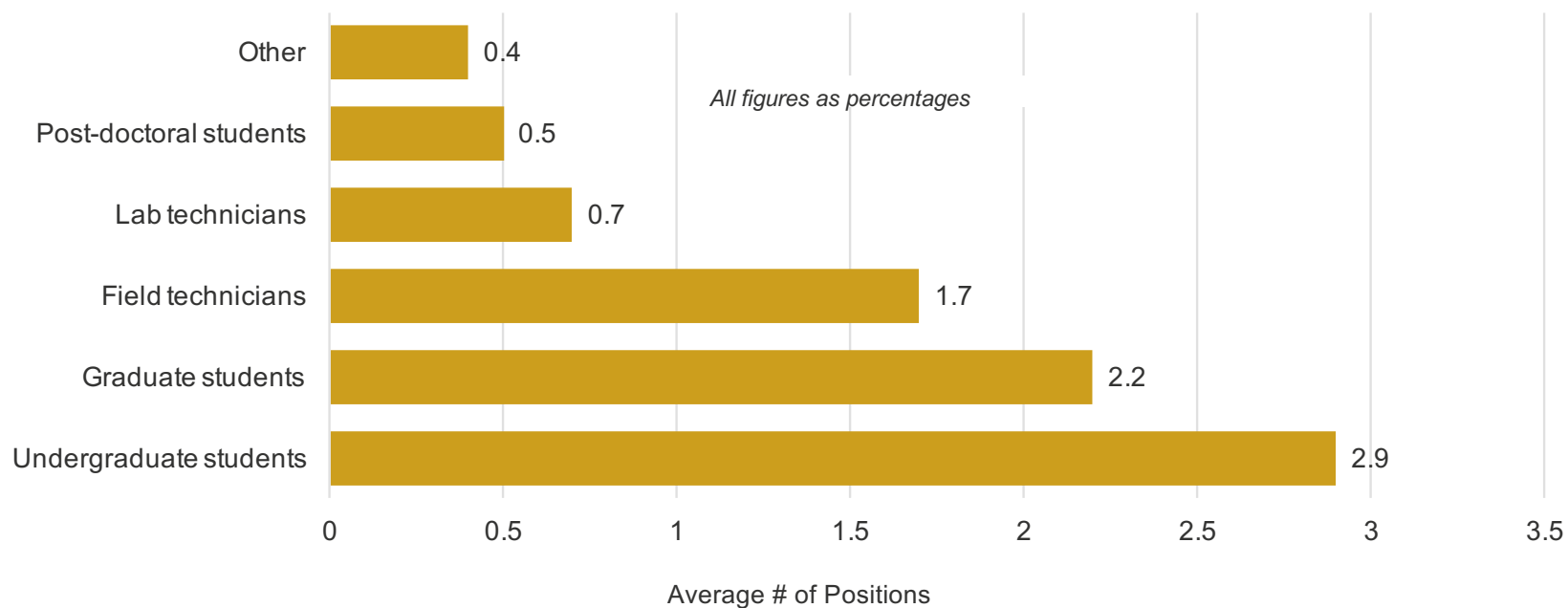


Crop Biology



SOURCE: Shelton, A. C., and W. F. Tracy. 2017. Cultivar Development in the U.S. Public Sector. *Crop Sci.* 57:1823-1835. doi:10.2135/cropsci2016.11.0961

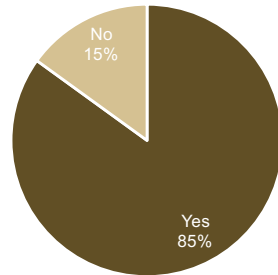
Breeders Report Employing an Average of 8.4 Persons



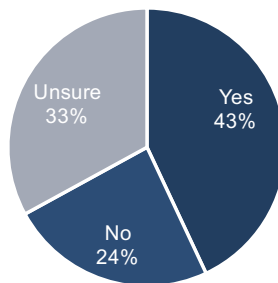
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Breeding Programs Encourage and Incentivize Cultivar Development, But Only 43% of Breeders Report That Their Position Would Be Replaced if they Left

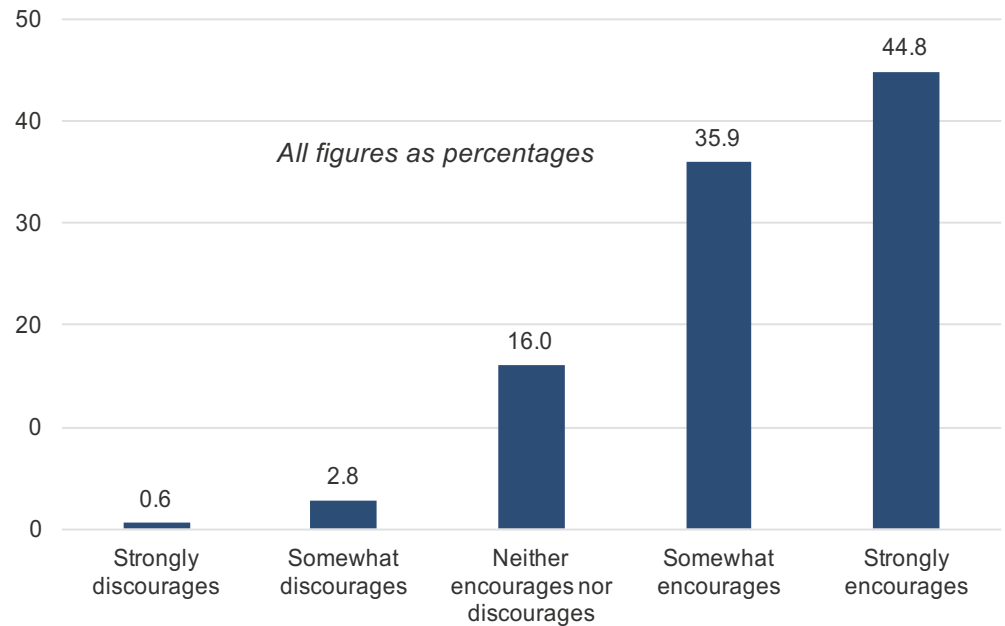
“If you work for an institution that offers tenure, does cultivar development count towards the tenure process?”



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

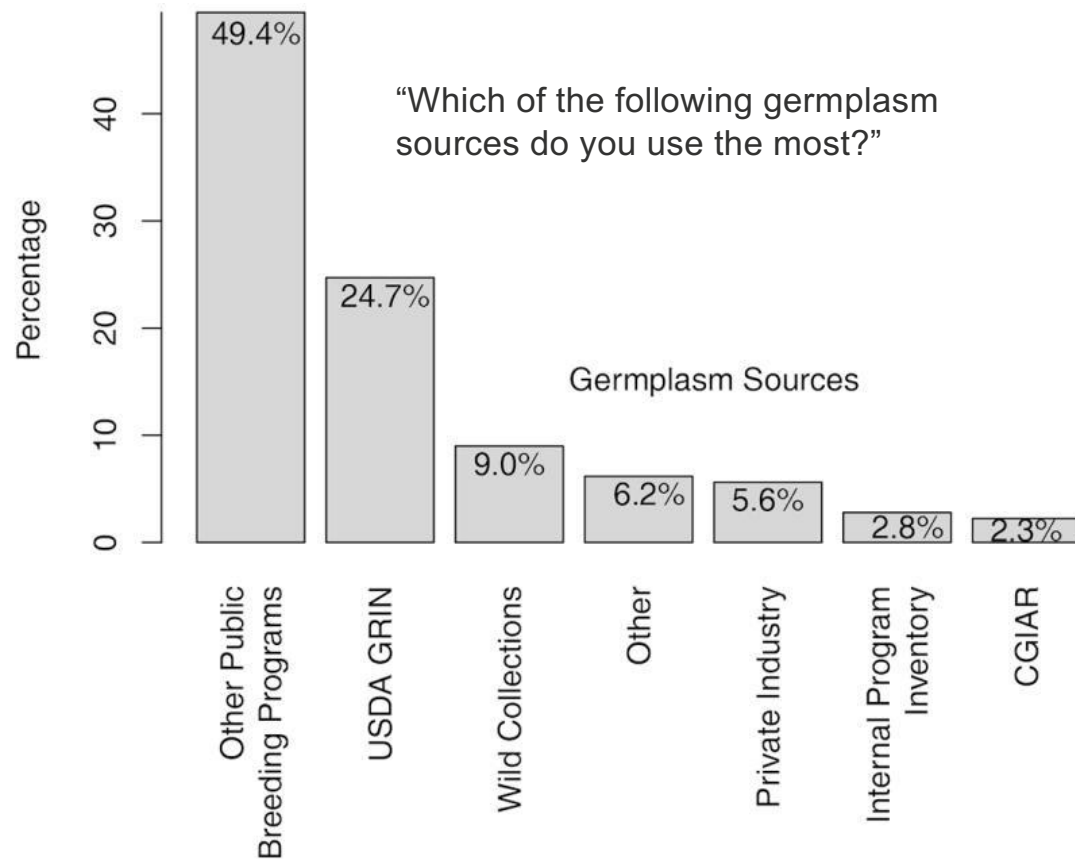


“How much does your institution encourage your cultivar development work?”



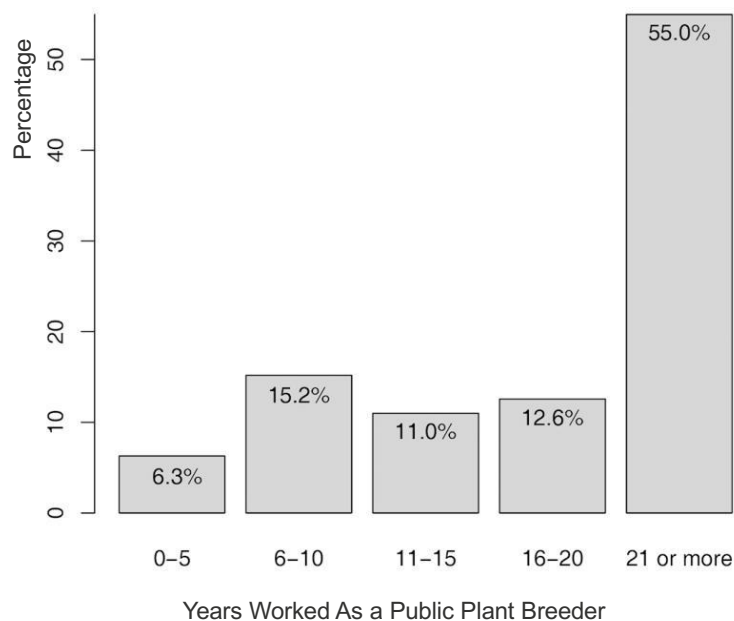
SOURCE: Shelton, A. C., and W. F. Tracy. 2017. Cultivar Development in the U.S. Public Sector. Crop Sci. 57:1823-1835. doi:10.2135/cropsci2016.11.0961

Breeders Most Commonly Source Germplasm From Other Public Breeding Programs

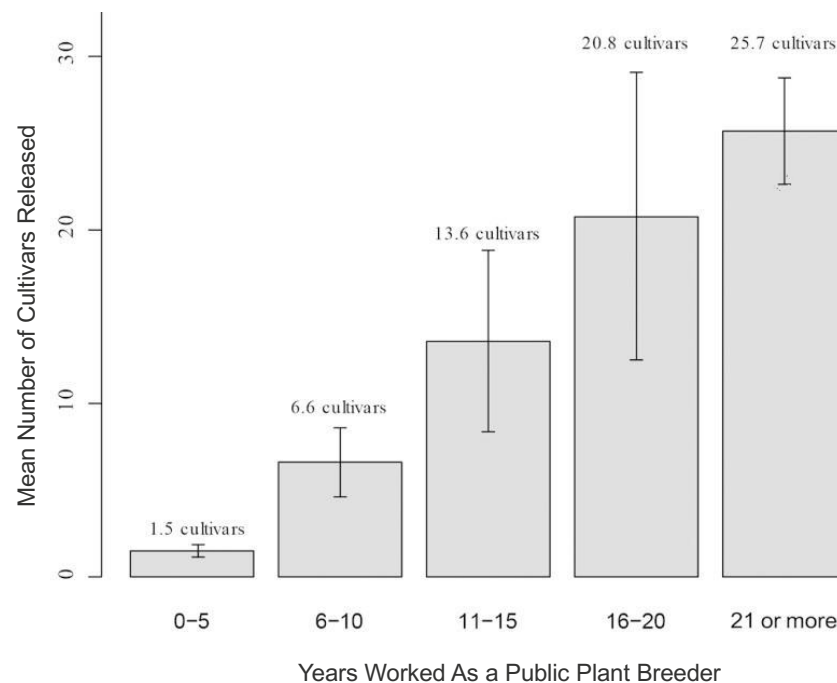


Positive Correlation Between Years Worked as a Public Plant Breeder and the Number of Cultivars Released

How many years have you worked as a plant breeder?



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

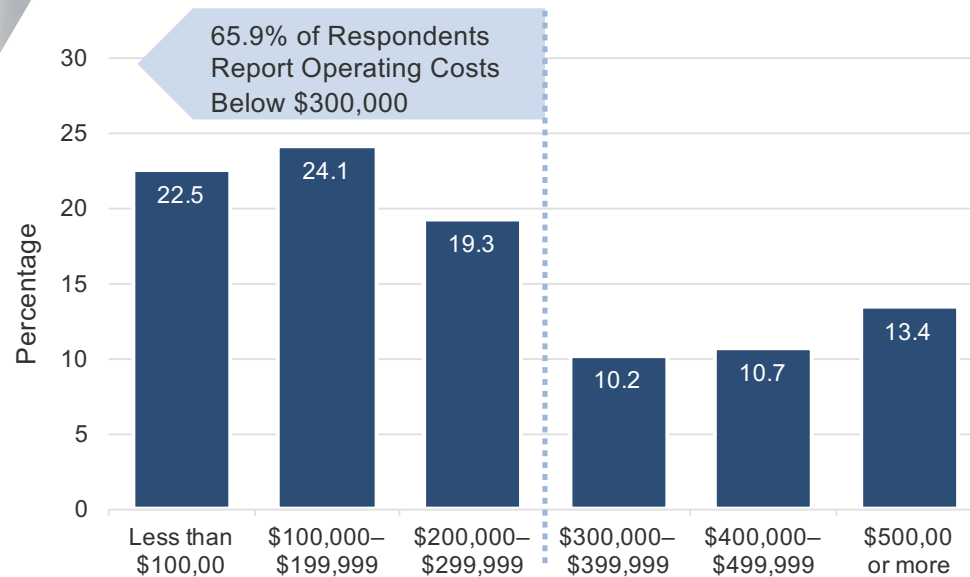


Breeders' Employers Contribute Less Than 25% of Annual Operating Costs

Funding Source	% of Breeding Program Funding
Employer	24.1
Commodity check-off programs	17.8
USDA competitive grants	14.2
Royalty money	12.3
Private industry	12.3
Federal formula funds	11.6
Other	7.6

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 ($N = 177$).

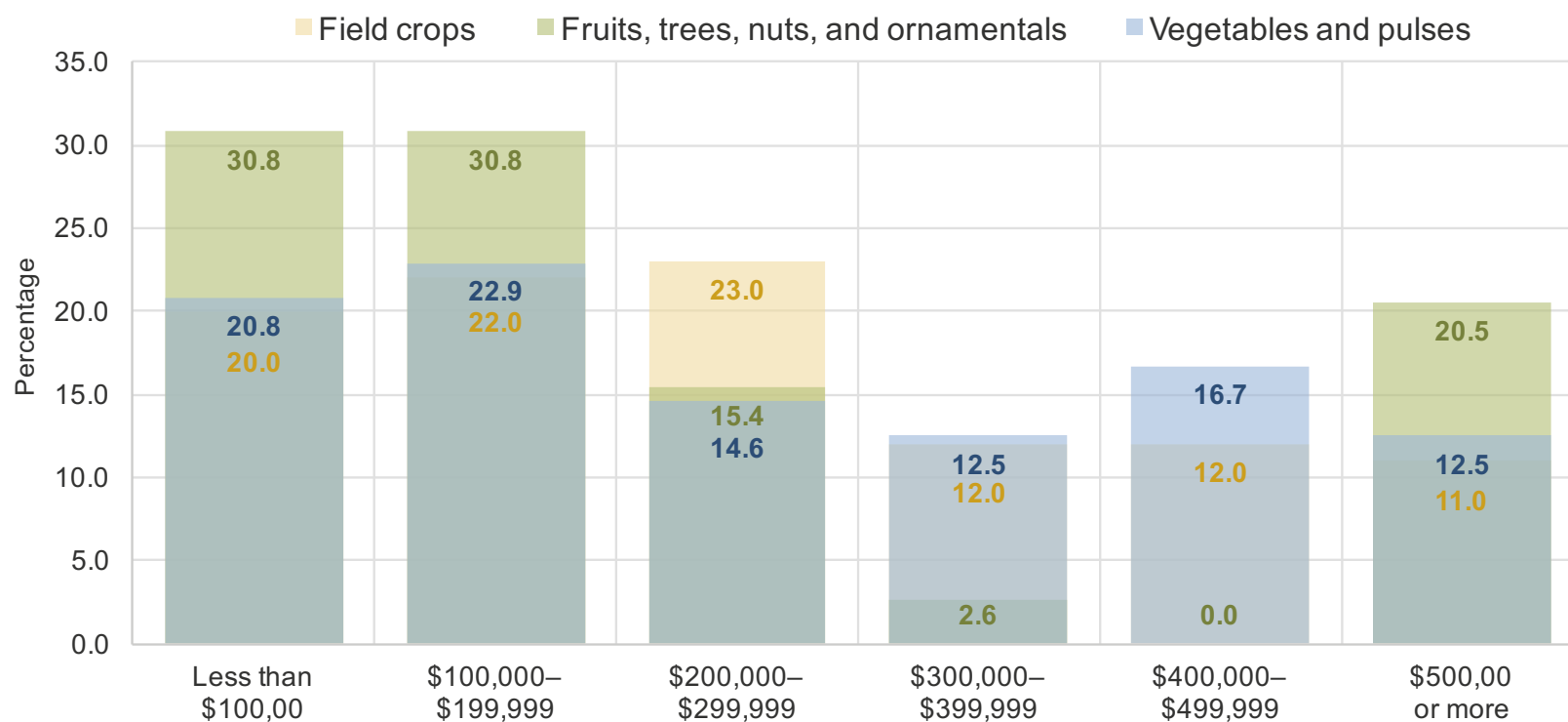
Distribution of Breeding Programs' by Annual Operating Costs



SOURCE: Shelton, A. C., and W. F. Tracy. 2017. Cultivar Development in the U.S. Public Sector. *Crop Sci.* 57:1823-1835. doi:10.2135/cropsci2016.11.0961

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

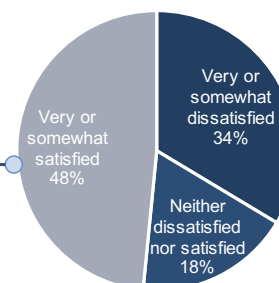
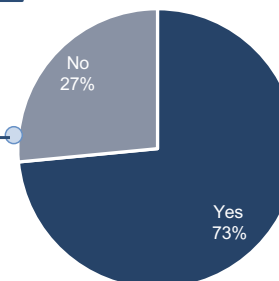
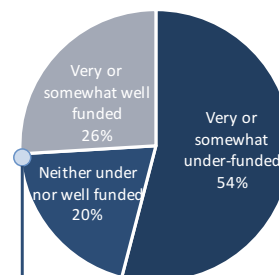
Number of Respondents	
All	187
Field crops	100
Fruits, trees, nuts, and ornamentals	39
Vegetables and pulses	48



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

		Breeding Programs by Annual Operating Costs					
<i>All figures as percentages</i>	N	Less than \$100,00	\$100,000– \$199,999	\$200,000– \$299,999	\$300,000– \$399,999	\$400,000– \$499,999	\$500,000 or more
Do you feel your program is:							
Very or somewhat under-funded	100	34.0	30.0	17.0	10.0	4.0	5.0
Neither under nor well funded	37	13.5	27.0	18.9	8.1	16.2	16.2
Very or somewhat well funded	48	6.3	10.4	22.9	12.5	20.8	27.1
Does your program generate royalties?							
Yes	133	15.8	22.6	22.6	9.8	13.5	15.8
No	48	43.8	31.3	4.2	12.5	4.2	4.2
Satisfaction with royalty distribution:							
Very or somewhat dissatisfied	43	14.0	18.6	16.3	18.6	18.6	14.0
Neither dissatisfied nor satisfied	23	8.7	30.4	21.7	0.0	13.0	26.1
Very or somewhat satisfied	62	19.4	22.6	25.8	6.5	11.3	14.5



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Respondent Responses Stratified by Their Breeding Programs' Reported Annual Operating Costs

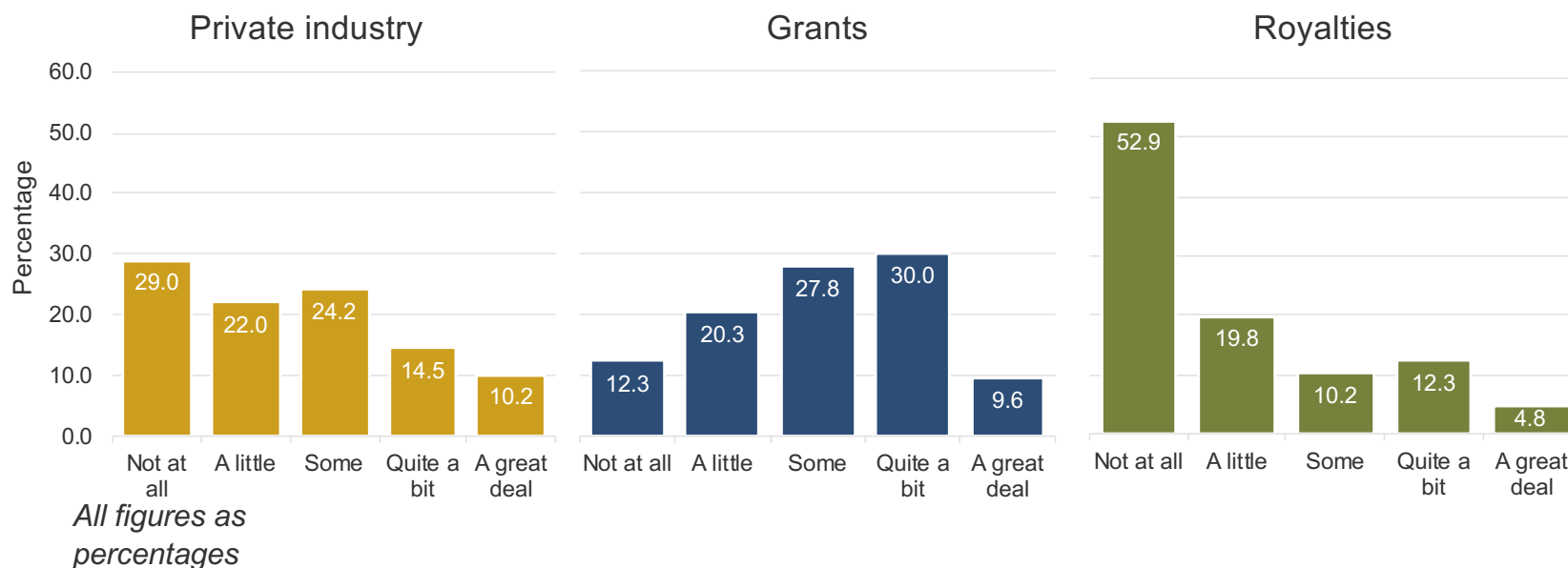
All figures as percentages

	<i>N</i>	Less than \$100,00	\$100,00– \$199,999	\$200,00– \$299,999	\$300,00– \$399,999	\$400,00– \$499,999	\$500,00 or more
Crop type							
All	187	22.5	24.1	19.3	10.2	10.7	13.4
Field crops	100	20.0	22.0	23.0	12.0	12.0	11.0
Fruits, trees, nuts, and ornamentals	39	30.8	30.8	15.4	2.6	0.0	20.5
Vegetables and pulses	48	20.8	22.9	14.6	12.5	16.7	12.5
Years worked as a public plant breeder							
0–5 yr	11	27.3	27.3	9.1	9.1	27.3	0.0
6–10 yr	28	25.0	14.3	39.3	10.7	0.0	10.7
11–15 yr	20	20.0	30.0	25.0	15.0	5.0	5.0
16–20 yr	24	20.8	41.7	12.5	8.3	8.3	8.3
21 yr or more	103	22.3	21.4	14.6	9.7	13.6	18.4
Do you feel your program is:							
Very or somewhat under-funded	100	34.0	30.0	17.0	10.0	4.0	5.0
Neither under nor well funded	37	13.5	27.0	18.9	8.1	16.2	16.2
Very or somewhat well funded	48	6.3	10.4	22.9	12.5	20.8	27.1
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Neither dissatisfied nor satisfied	23	8.7	30.4	21.7	0.0	13.0	26.1
Very or somewhat satisfied	62	19.4	22.6	25.8	6.5	11.3	14.5
Will your position be replaced?							
Yes	77	9.1	13.0	23.4	14.3	15.6	24.7
No	43	41.9	25.6	9.3	11.6	2.3	9.3
Unsure	59	27.1	39.0	18.6	3.4	11.9	0.0

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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.


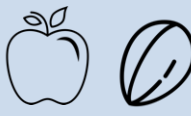



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Intellectual Property Rights Are Routinely Secured on Public Breeders' Cultivars

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.

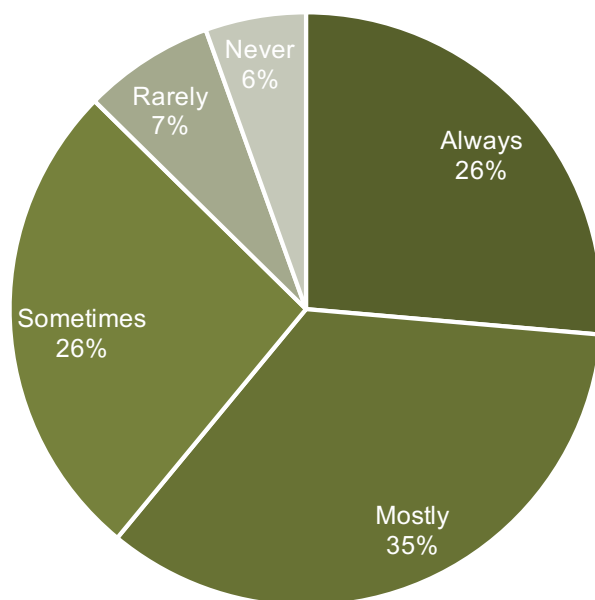
All figures as percentages

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

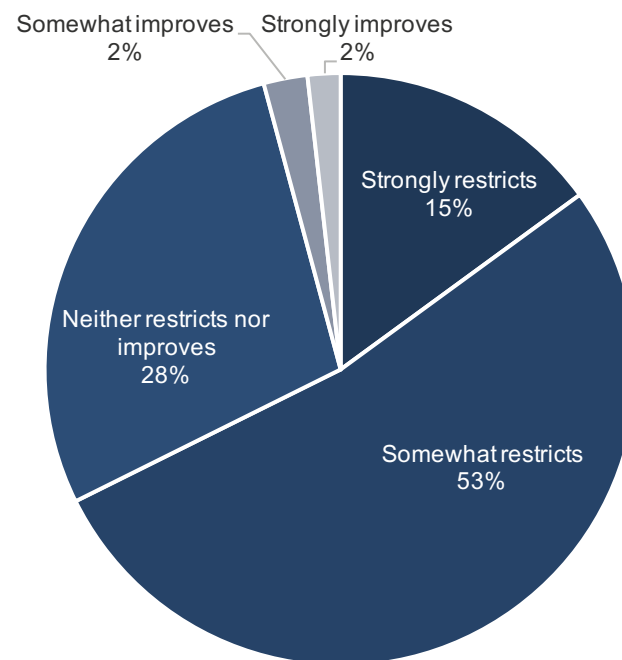
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Breeders Commonly Share Germplasm (95%), but the Associated Material Transfer Agreements Restrict Breeders' Freedom to Operate

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



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



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